
1837
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

THE

AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES

VOLUME VIII.
JULY TO DECEMBER, 1891.

MINNEAPOLIS, MINN.
THE GEOLOGICAL PUBLISHING COMPANY.
1891

C. KIMBALL PRINTING CO., PRINTERS.

CONTENTS.

JULY NUMBER.

AUGUST NUMBER.

SEPTEMBER NUMBER.

ERRATUM: On page 291, line 7, for "Microdescies," read Microdiscus.

THE

AMERICAN GEOLOGIST

VOL. VIII. JULY, 1891. No. 1.

THE GREYLOCK SYNCLINORIUM.*

T. NELSON DALE, Newport, R. I.

The topography of the NW. part of Massachusetts is marked by three main parallel mountain masses having the N. NE. trend common to the Appalachian system. The most westerly of these is the Taconic range, the crest of which divides the states of New York and Massachusetts; the most easterly, situated about ten miles east of the N. Y. line is Hoosac Mt. traversed by the Hoosac tunnel, while the central one is Mt. Greylock, the prevailing rock of which, farther south, merges in that of the Taconic range. Mt. Greylock forms a topographical unit, measuring about 14 miles in length and averaging about 5 in width, and consists mainly of one central and two lateral subordinate ridges with the same N. NE. trend. The "saddle," from which it derives one of its ancient names, and which is a conspicuous object all through Berkshire county, is formed by a SW. bend in the central ridge between Greylock summit proper (3505 feet above sea level) on the north and Saddle Ball (3300 ft.) on the south. These are about two miles apart, and the lowest part of the saddle is 2900 ft. above sea level.

*Abstract of a report by T. Nelson Dale, Assistant Geologist U. S. G. S. to Raphael Pumpelly, Geologist in charge of the Archean Division, covering field work done by the writer in 1886-1888 assisted during a portion of the time by Wm. H. Hobbs. This abstract is published by permission of the Director of the U. S. Geol. Survey. The full report, amply illustrated, and entitled "Mt. Greylock, its areal and structural geology," goes to make up, together with a monograph by Raphael Pumpelly and one by J. E. Wolff, a memoir on the Green mountains, now in course of publication by the Survey.

Situated right in the midst of the Taconic region Mt. Greylock has been often alluded to during the last seventy years in the much debated "Taconic Question." Professors C. Dewey, E. Emmons, E. Hitchcock and J. D. Dana are the principal authorities on the geology of the mountain. The general synclinal structure of the mass and also the fact that it consists mainly of certain schists underlaid by limestone are well known. Professor Dana has also conjectured the anticlinal structure of the hollow which separates two of its ridges.

The following description is based upon the new 20 ft. contour map made by the topographers of the U. S. Geological Survey, and upon extended and laborious geological explorations, and upon the careful microscopic study of lithological specimens by Mr. J. E. Wolff. The results of modern topography, orography and petrography have been brought to bear upon the subject.

Structural. The rocks are all metamorphic and of few kinds: crystalline limestones and various schists, micaceous (sericitic) chloritic, albitic, pyritiferous, plumbaginous, calcareous. The key to the real structure of the mountain is in clearly distinguishing cleavage-foliation from stratification-foliation, the apparent dip and strike being generally entirely misleading excepting at contacts and even there sometimes.* The phenomena of cleavage and stratification as they occur on Mt. Greylock are illustrated by a number of typical cases which substantiate and illustrate the following structural principles:

I. Lamination in schist or limestone may be either stratification-foliation or cleavage-foliation or both. In rare instances traces of false-bedding occur in the limestone. To establish conformability the conformability of the stratification-foliations must be shown. The importance of this is manifest and it would seem too elementary a principle to be stated here were it not that at one locality where the limestone and schist are in apparently conformable contact, their cleavage-foliations alone are conformable while the stratification-foliation of the schist is at right angles to that of the limestone owing to a fault.

II. Stratification-foliation in the schist is indicated by: (*a*) the course of minute but visible plications; (*b*) the course of micro-

*The more important references to the subject of cleavage occur in the writings of Sedgwick, Phillips, Darwin, Sharpe, Sorby, Tyndall, Rogers, Kyerulf, Heim, Daubrée, Jannettaz, Reusch, Bonney, Cadell and Harker.

scopic plications; (*c*) the general course of the quartz laminæ whenever they can be clearly distinguished from those which lie in the cleavage planes.

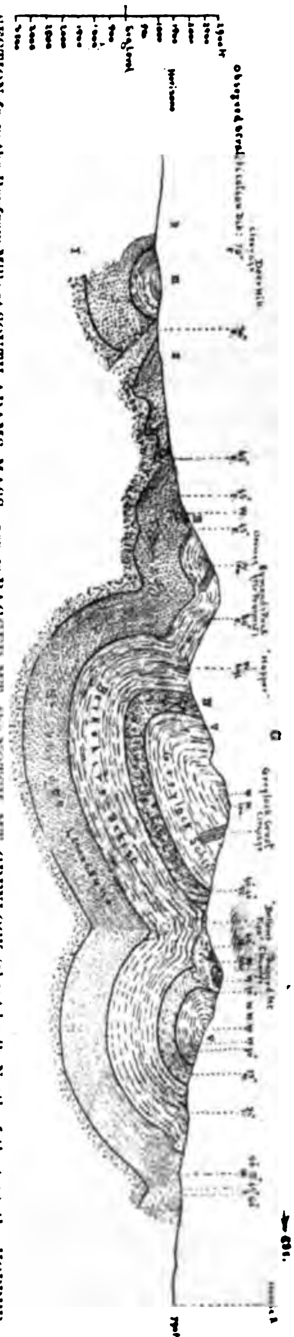
III. Cleavage-foliation may consist of: (*a*) planes produced by or coincident with the faulted limbs of the minute plications; (*b*) planes of fracture resembling joints on a very minute scale with or without faulting of the plications; (*c*) a cleavage approaching "slaty cleavage" in which the axes of all the particles have assumed either the direction of the cleavage or one forminga very acute angle to it and where stratification-foliation is no longer visible.

IV. A secondary cleavage resembling a minute jointing occurs in scattered localities.

V. The degree and direction of the pitch of a fold are indicated by those of the axes of the minor plications on its sides.

VI. The strike of the stratification and cleavage-foliations often differ in the same rock and are then regarded as indicating a pitching fold.

VII. Such a correspondence exists between the stratification and cleavage-foliations of the great folds and those of the minute plications that even very small specimens properly oriented give in many cases the key to the structure over a large part of the side of a great fold.*



SECTION from the Renfrew Mills at SOUTH ADAMS, MASS., across RAGGED MT. the NOTCH, MT. GREYLOCK (about 1 mile North of the top), the HOPPER, MT. PROSPECT and the north end of DEER HILL, showing the PROBABLE STRUCTURE at the GREYLOCK SYNCLINORIUM.
The surface outline is based upon the U. S. GEOL. SURVEY Contour Map of 1885. Horizontal and Vertical Scale 1-62500 or 1 inch to the mile.
The observed Stratification dips are indicated as well as the Cleavage.

*The full report will contain reproductions of photographs of slightly enlarged rock sections, and also sketches and diagrams illustrating these principles.

On these structural principles thirteen complete and six partial sections have been constructed across the Greylock mass. These show that it consists of a series of more or less open or compressed synclinals and anticlinals which, beginning at the north end (North Adams), increase southerly in number and altitude with the increasing width and altitude of the schist mass, and then, from a point about a mile and a half south of the summit, begin to widen out and diminish in number and hight until they finally pass into a few broad and low undulations. Mt. Greylock with its subordinate ridges is a synclinorium consisting in its broadest portion of ten or eleven synclinals alternating with as many anticlinals. While the number of these minor synclinals at the surface is so considerable, in carrying the sections downwards they resolve themselves chiefly into two great synclinals with several lateral and smaller ones. The larger one forms the central crest of the mass, the smaller one east of it forms Ragged Mt., the subordinate ridge on that side. The major central synclinal is so compressed near the highest part of the mountain and its axial plane is so inclined to the east, i. e. it dips to the west, that the strata which underlie it have on its west side a westerly dip. Further south this synclinal opens out and all the relations become more normal. On either side of these two main synclinals the subordinate folds are more or less open and have their axial planes vertical or inclined east or west.

The accompanying figure 1, shows one of the more important of these cross sections, Section G, which passes about a mile north of the top.* That which crosses about a half mile south of the top, and through the Bald Mt. spur on the south side of the "Hopper," is even more complex in its western portion.

There are long undulations in the axes of these synclinals as shown in several longitudinal sections. The side or edge of this great double trough is at the extreme north end of the mass and its southern about eight miles distant. South of these main troughs is another shallower pair. The same N. S. trough structure prevails also through all the subordinate lateral folds. The deepest part of the synclinorium appears to be under the saddle between the two summits, Greylock and Saddle Ball.

*In order to show the current conceptions of the topography and geology of Greylock the reader is referred to Dana's Manual of Geology, 3d edit., 1880, p. 213 where Emmons' section of the mountain is reproduced.

Traversing the folds of this canoe-like complex synclinorium is a cleavage-foliation sometimes microscopically minute, dipping almost uniformly east. This cleavage-foliation is generally distinct from the "slaty cleavage" early described by Sedgwick, Sharpe, and Sorby, and reproduced experimentally by Tyndall and Jannettaz; but consists sometimes of a minute joint-like fracturing of the laminæ, but more generally of a faulting of the laminæ as the result of their extreme plication—a mode of cleavage (ausweichungs-clivage) so well described by Heim,* and recently reproduced in part by Cadell † by a slight modification of the experiments made by Alphonse Favre of Geneva in 1878.‡ This fault-cleavage, when carried to its extreme, results in a form of cleavage very nearly approaching, although not identical with "slaty cleavage." To the unaided eye all traces of stratification-foliation are lost and even under the microscope they are so nearly lost as to be of little or no avail in determining the direction of the dip.§

Lithological Stratigraphy. There are five more or less distinct horizons in the Greylock mass. Beginning above: *The Greylock Schists*: muscovite (sericite) chlorite and quartz schist, with or without biotite, albite, octahedral magnetite, tabular crystals of interleaved ilmenite and chlorite, ottrelite, microscopic rutile and tourmaline. Thickness 1200 to 2000 feet. Part of Emmons' Pre-Cambrian or Lower Taconic No. 3, "Talcose Slate." Walcott's Hudson River (Lower Silurian).

The Bellows Pipe Limestone, (so named from its occurrence at the "Bellows Pipe" in the notch between Ragged Mt. and Greylock): Limestone more or less crystalline, generally micaceous or pyritiferous, passing into a calcareous mica schist or a feldspathic quartzite or a fine grained gneiss with plagioclase and occasional

---

*A. Heim. Mechanismus der Gebirgs bildung, im Anschluss an die Geologische Monographie der Toedi-Windgællen Gruppe. Basel 1878.

†Henry M. Cadell. Experimental Researches on Mountain Building. Paper read before the Royal Society of Edinb., Feb. 20, 1888. Transac. Roy. Soc. Edinb. Vol. XXXV, part 7, p. 337, 357. Abstract in Nature, Vol. 37, p. 488, Mch. 23, 1888. Third series of experiments.

‡Alphonse Favre. The formation of Mountains. Nature, Vol. XIX, 1878, p. 103.

§Slaty cleavage results from the destruction of the small laminæ by the breaking up of the sedimentary arrangement of the particles and changing the direction of the axes of all the particles. In this connection see: Alfred Harker, The causes of Slaty Cleavage; compression v. shearing. Geological Magazine, London, 1885, p. 15, and also by the same author; On the Successive Stages of Slaty Cleavage. *Ibid*, p. 266.

grains of microcline, zircon. The more common minerals are graphite, pyrite, albite, microscopic rutile and tourmaline; rarely galena and zinc blende. Thickness 600–700 feet. This horizon was entirely overlooked by Emmons, as his section happened to cross the mountain where this upper limestone is covered with drift. It belongs in his Lower Taconic No. 3, and in Walcott's Hudson River as do the Greylock Schists.

The Berkshire Schists (so named from their prevalence throughout Berkshire county): In character like the Greylock schists, but more frequently calcareous especially towards the underlying limestone. Thickness 1000 to 2000 feet. Also forming a part of Emmons' Pre-Cambrian or Lower Taconic No. 3, "Talcose Slate," and Mather's, Hall's, and Walcott's Hudson River (Lower Silurian). Considerable allowance should be made for thickening in consequence of plications in the estimates of the thickness of both the Berkshire schists and the Greylock schists.

The Stockbridge Limestone. Limestone crystalline, in places a dolomite, quartzose or micaceous, more rarely feldspathic. Very rarely fosiliferous. Galena and zinc blende rare. Irregular masses of iron ore (limonite) associated sometimes with manganese ore (pysolusite) and with siderite, occasionally replaced to a small extent by quartzite. Thickness 1200 to 1400 feet. Emmons' Pre-Cambrian Lower Taconic No. 2, (Stockbridge Limestone), Dana's Lower Silurian, Walcott's Trenton Calciferous and Chazy (Lower Silurian). From Mr. Foerste's and Mr. Wolff's recent discoveries in Vermont some of the lower part of this horizon may be Cambrian.*

The Vermont Formation. Quartzite, cropping out in the Greylock area only once (See Section G.) but possibly underlying the entire mass. Thickness 870 feet. Emmons' Pre-Cambrian, Lower Taconic, I. Granular quartz, Dana's Cambrian, Walcott's, in part Lower Cambrian, "Olenellus."

It should be noted that the maximum thickness estimated does not exceed the thickness usually attributed to the Lower Silurian in the Appalachian region.

Areal Geology. The geological map of Greylock and the adjacent masses presents a great body of the schists of the horizon of the Berkshire schists almost surrounded by the underlying

*J. Elliot Wolff, on the Lower Cambrian Age of the Stockbridge limestone, Bulletin of the Geological Society of America, Vol II, 1891.

Stockbridge limestone. The Berkshire schists send out tongues into the Stockbridge limestone area. There are also re-entering angles of limestone in the schist area corresponding to anticlinals. There are isolated schist areas which are more or less open synclinals and isolated limestone areas which are compressed anticlinals forced up through the overlying schists or truncated by erosions. Their relations are repeated between the upper limestone (Bellows Pipe limestone) and the Greylock schist.

Relations of Geology to Topography. The physically and chemically more resistant schists form the more elevated portions and the steeper slopes, while the broad valleys and gentle undulations about the mountain generally correspond to limestone areas. The upper limestone and calcareous schist constitute the benches of agricultural land high up on the sides of the mountain and "the notch" so early settled; and to the presence of this rock also, together with a northerly pitch, is due the deep incision in the central crest between Saddle Ball and Round Rocks. The N.-S. part of the Hopper cut was occasioned by the trend and upturned edges of the calcareous belt. A minor anticlinal occurs on the west side of this part of the Hopper. The deep E.-W. incisions on both sides of the mountain are the results of erosion crossing the strike, while the great spurs on the west side are portions of the original mass left by this erosion. The saddle between Greylock summit and Saddle Ball is due to the central synclinal of the mass, and the saddle seen in the mass from Mt. Equinox on the N.N.W. is due to the great trough in the central synclinal. The center of this trough is the deepest part of the entire synclinorium.

Newport, R. I., April 22, 1891.

THE FUEL RESOURCES OF COLORADO.

By A. Lakes, Golden, Col.

RECENT DEVELOPMENT OF THE COAL FIELDS.

Up to the past five or six years the comparatively small areas of coal discovered and developed within the reach of railroads, were confined to the narrow eastern and northeastern border of our mountains, and were monopolized by two or three companies, or leagued with two or three railroads. The markets were local also. Now, far greater and more important fields, with larger seams and

superior quality of coal have been discovered and partially developed on the western slope of the Colorado range. There are now twenty companies at work where before there were but one or two, and these not merely on the old fields, but on the new. From a once local trade we have now come to supply many neighboring States as far east as the Missouri river. From nothing as a coal State, Colorado has leaped into the front ranks.

EASTERN COAL AND THAT OF COLORADO COMPARED.

It has been by no means easy to convince eastern men either of the quality of Colorado coal, or of the area of its fields as compared with similar data of eastern states. They have long thought of our coals as "lignites," little better than peat, owing to the fact that they were so dubbed by Hayden in his report of 1873. This was true enough of the northern field about Boulder, but wholly unjust to the great bulk of our coal fields, which produce true bituminous coal—the same in quality and character as that of Pennsylvania. We have coals that not only produce good coke, equal, some of it to that of Connellsville, but even anthracite, limited in quantity, similar to that of the eastern states. This fact is emphasized by the leading coal expert and geologist of the eastern states, Dr. J. S. Newberry, of the Columbia School of Mines of New York, who says of our Colorado fields west of the range:

"Here we see sometimes eight to ten different seams in one section, reaching a united thickness of forty to fifty feet, of a quality which will compare with any known in the world. Owing to peculiar conditions this coal forms several varieties, each of which has its special uses. Here is anthracite, as hard and bright as any mined in eastern Pennsylvania; semi-bituminous coals, similar to those of Blossburg and Cresson, but more compact and pleasanter to work, transport and use; bituminous coal, yielding a coke as good as that of Connellsville, and open-burning furnace coals similar to the famous Briar Hill coal, of Ohio, and of equal value. These coals are of unusual purity, sometimes containing 3 per cent. and rarely more than 5 per cent. of ash, with little sulphur or phosphorus."

Our fields belong geologically to the Cretaceous, but what old age and pressure have done for the eastern coals, has been accomplished for ours by the heat of volcanic eruptions attendant upon mountain upheaval.

DISCOVERY OF THE COAL FIELDS.

A glance at Mr. R. C. Hill's map in "Hall's History of Colorado," gives some idea of the great area occupied by our coal fields, and their distribution in the state. And since formerly only that marked "The Northern Colorado Field" was known and worked, it will appear how largely the knowledge of our coal resources has increased within the past few years. This northern field developed at Marshall, Erie, Louisville and Golden was formerly the main supply of Denver and the mountain towns. Later the southern portion of the field was developed and worked from time to time at Franceville, near Colorado Springs. Excellent coal, too, was opened on the small isolated field near Canon City. But the most important discovery was made some years later in the Raton field, where the coal was found to be not only bituminous, but also capable of making very fair coke, a commodity long desired by the smelters, who up to this time had to rely upon Pennsylvania.

Later, a mine was opened at Crested Butte, across the range, which produced a first-class coke, equal to that of Connellsville. Since this epoch of coke discovery, large areas of coking coal have been discovered in various parts of the state.

In the same area a small field of excellent anthracite was discovered, covering a few hundred acres. Thus, in a very short time, our reputation as a so-called "lignite" bearing state had been raised to that of a first-class bituminous, coke and even anthracite producing region.

THE GRAND RIVER COAL FIELDS.

The contest for a path to Utah between the Midland and the Rio Grande railways led to the discovery and development of still another new field, along the banks of the Roaring Fork and Grand river, even richer than the rest, in the varieties and great thickness and number of seams of bituminous, domestic, coking, and anthracite coals. The coking coals were developed by the Marion mines, near Cardiff, and the coke found to be as good as Connellsville. The great, thick and numerous seams of bituminous and domestic coal were, and still are being developed all along the great Hogback, from Glenwood to Meeker, a distance of forty miles. Thus began the development of the great Grand River field, which for area, variety and excellence of its coal is the most important field of the future in Colorado. As yet its out-

skirts only have been touched, and there is a vast area for future enterprise, whilst north and beyond it is yet another large and untouched field known as the Yampa.

The coal of this Grand River field has a further importance from its close proximity to the greatest iron deposits so far discovered in Colorado, such as those of the Iron King, at White Pine, about thirty miles from Gunnison City, and the Cumberland iron mine, in Pitkin county, also within fair distance of this great coal field.

SOUTHWESTERN OR LA PLATA FIELD.

Meanwhile in southwestern Colorado the Rio Grande railway had entered and discovered another large field, covering thousands of square miles, and extending from Colorado into New Mexico and Arizona, known as the La Plata field. Here is an immense amount of coal in bodies from seventy feet down to five feet in thickness; yet over this great area the development is restricted to four or five small mines, one at Monero, another at Florida, and three or four about Durango, doing a very local trade. This small development is due to the possession of much of the field by the Ute Indians, and to the fact that but one railroad penetrates the region. The coal is bituminous, and over certain areas makes fine coke.

Besides these large fields, there are several smaller isolated ones, such as one in North Park, with thick seams of lignitic coal, another in South Park, for some years developed by the Union Pacific, and another undeveloped field on "Tongue Mesa," near Montrose.

NORTHERN COLORADO COAL FIELD.

This field extends north from Boulder into the Laramie plains of Wyoming, and south to Colorado Springs. Its approximate eastern boundary is a line drawn north and south some forty miles east of the mountains. This field has long been developed in Boulder county by the Marshall, Erie and Louisville mines, also by mines at Golden and Ralston. Marshall is one of the oldest mines in the state, having been worked for at least twenty years. By a series of faults, accompanied by erosion, the coal has locally been brought near to the surface at a gentle dip of 5 degrees. The principal seam is six to eight feet thick. The coal is a good, pure, high-class lignitic coal, not coking, but well adapted to all purposes where extraordinary heat is not required. A large area has been worked out, a good deal burnt out by spontaneous com-

bustion, and an unknown amount presumably left. The development is sometimes impeded by the faults which cut off the continuity of a seam.

The following is an analysis of Marshall coal:

	Per Cent.
Water	10.73
Volatile	44.11
Fixed carbon	38.38
Ash	6.11

The area of the Colorado portion of the northern field is estimated by Hills at 6,800 square miles, the accessible portion at 405 square miles, and the available coal at 2,568,600,000 tons.

From Franceville, for about thirty miles south, there are no developments until we reach Canon City, on the south bank of the Arkansas river where is a small isolated field, twelve miles long by two miles broad, carrying a seam four to five feet wide of non-coking bituminous coal, which has long been a favorite fuel from its high calorific power and general purity. The gentle dip of the strata admits extensive development. There are three or more companies developing this small field at present.

THE SOUTHWESTERN FIELD.

From the Arkansas river to the Huerfano river, a distance of fifty miles, another barren space, and then we meet the northern extremity of the great Raton plateau and Raton coal fields. Some of this coal has been burnt, or changed into natural, but worthless coke by volcanic dykes with which the region abounds. As a whole, however, it represents an enormous amount of bituminous, domestic and coking coal. The cause of this change from a lignitic to a bituminous and coking character may be found in the great volcanic manifestations of this area.

The following analysis of Al Moro coal gives:

	Per Cent.
Water	0.54
Volatile matter	30.29
Fixed carbon	54.43
Ash	14.74
Total	100.00

Hills estimates the available area of this field in Colorado at 473 square miles, and the available coal at 4,490,200,000 tons. In former years there were but two companies working in this great field, now there are a dozen.

From the fields of the eastern slope we turn to those on the

west slope of our mountains. We cross the Sangre de Cristo range, the broad San Luis park and the Conejos range, seeing no coal for over 100 miles. From the Conejos range we look down on a region of endless plateaus, representing the La Plata coal fields. Over this large area there is, as we have stated, but half a dozen small mines. One body of coal on the Animas river, below Durango, is seventy feet thick, caused by the running together of several seams. It is developed at the Carbonero and La Plata mines. The great body is traceable for several miles along the "hog-backs" by a valley caused by the washing out of the softer coal. The individual seams composing this mammoth body can be worked individually to advantage, but worked collectively the result would be a high per cent. of ash from the admixture of shale "partings." Close to the town of Durango a seam five feet thick, of excellent quality, is worked by the San Juan and Porter mines. The coal of all these seams makes very good coke, but the market of it is at present local. The drawbacks to this coal field are its distance from the main central market, the presence of only one line of railroad, and the proximity of the Ute reservation. When some of these obstacles are removed there is a good future for the region.

An analysis of the smaller seams is:

	Per Cent.
Water	0.63
Volatile matter	34.70
Fixed carbon	57.30
Ash	7.37
Total	100.00

And for the larger seams:

	Per Cent.
Water	1.30
Volatile matter	39.70
Fixed carbon	54.78
Ash	4.22
Total	100.00

Hills estimates the Colorado portion of this field 1,250 square miles, the available portion at 300 square miles, the available coal at 3,387,200,000 tons.

FIELDS OF NORTHWESTERN COLORADO.

From Ouray we go northeast to Crested Butte. Here is a small portion of the Grand River field isolated by a circle of volcanic mountains, forming the Elk range. The heat from these volcanic

sources has altered the coal into several varieties. We have bituminous, coking, semi-anthracite and true anthracite, the alteration being more or less great, according to distance from volcanic heat.

The anthracite portion is limited to an area of about 500 acres; the seam is six feet thick and yields an anthracite as hard and lustrous as that of Pennsylvania. Its analysis is:

	Per Cent.
Water	1.56
Volatile matter	5.93
Fixed carbon	88.76
Ash	3.75
Total	100.00

This mine is at present the main anthracite supply of Colorado.

An old analysis of the Crested Butte coal gives:

	Per Cent.
Water	1.94
Votalite matter	38.18
Fixed carbon	56.80
Ash	3.08
Total	100.00

Coke from this coal now analyzes as follows:

	Per Cent.
Water	.05
Volatile matter	1.15
Fixed carbon	89.12
Ash	9.62

This coke is not so strongly coherent as that of Trinidad, but in other respects is better.

At Crested Butte we leave the railroad and take horses and a camping outfit to explore the untouched areas of Grand River field. The boundaries of this field, as marked out by Hills, are as follows: It lies on the drainage of the Grand river and its tributaries in Pitkin, Garfield and Mesa counties, and a detached portion of it on White and Yampa rivers.

The coal of the southern end, beginning from Crested Butte, is traceable around mount Carbon to the Baldwin mines, thence west to Gunnison mountain, where, on Coal creek, are large seams of semi-coking and coking coal, with some anthracite. From mount Gunnison we follow the coal outcrop across the north fork of the Gunnison around Grand Mesa to Hogback canon on the Grand river, where sixteen miles above Grand Junction seams of domestic bituminous coal six to eight feet thick, appear on the sides of the canon. Thence to the Utah line along the Little Book cliffs

to Green river and beyond, the coal probably underlying a large tract of country east of the Wahsatch mountains.

Along the opposite margin coal is traceable west from Crested Butte, along the anthracite range and the south base of the Ragged mountains, down Crystal river to Coal Basin. Along the anthracite range and flanks of the Ragged mountains are local patches of very fine anthracite, but somewhat broken up, detached and difficult of access.

From New Castle the coal follows the course of the Great Hogback to Meeker, a distance of forty miles. Thence it bends in a curve in a northerly direction towards Yampa river, and appears again on White river, below the mouth of Piceance creek. After this it follows the Uintah range into Utah and Grand river.

In the coal basin at Jerome Park, and at the Marion and Sunshine mines near Cardiff, on the Roaring Fork, which lie around such eruptive centers as Mount Sopris and the Elk range, the coal is largely coking, producing a coke of great purity, at times equal to that of Connellsville. Hills estimates the coking area of this district at 353 square miles.

On the cliff face of the Great Hogback, 1,000 feet above the Grand river, we see exposed a great number of seams varying in thickness from twenty-two feet near the base, to ten and five feet near the summit. The coal along this hogback is first-class bituminous domestic coal, not coking, but freer from soot than those of a coking nature.

On the field around Meeker, owing to the absence of railroads, and the distance from markets, little development has been done. The coal appears like that at New Castle.

WHERE ANTHRACITE IS FOUND.

This Grand River field produces many good varieties of coal, the bulk of it being domestic and not coking. The anthracite area, so far as at present known, is in Colorado, confined to narrow areas along the Anthracite range, the flank of the great volcanic mountains, such as mount Marcellina and the Ragged mountains, and the small mesa at Crested Butte and the southern flanks of mount Gunnison, together with an undefined area in the Yampa field. Some of this so-called anthracite is more strictly semi-anthracite, excellent coal, but variable in thickness and quantity, and liable to have been broken up by the volcanic sheets which anthracised the coal. The largest and most promising an-

thracite area is one I saw this summer on the southwest base of Mount Gunnison, where a continuous seam, ten feet thick, overlaid by a sheet of volcanic rock, appears to underlie a considerable area, i. e., if we assume it to be co-extensive with the outcrop of the volcanic sheet. In the same vicinity were some of the finest seams of domestic coal I have yet seen in Colorado. They are some five or six in number, and vary from six to twelve feet in thickness, and lie at intervals one above another in the same section. There appears also to be an area of coking coal on the same property. The bulk of the coal area so far developed has been along the outskirts of the field. The center of the field is buried beneath the mountain plateaux of 5,000 to 10,000 feet thickness, of newer Tertiary strata. On the cliffs of these plateaux, instead of coal we see long black lines of asphaltum, with shale saturated with hydrocarbons to such a degree that they ignite with a match. From the latter, petroleum could doubtless be extracted and manufactured in the same manner as it used to be in the Eastern states before the great flowing oil, wells were discovered.

NATURAL GAS.

It was in this same region and set of strata that this summer I saw the first genuine and promising gas springs of any power or consequence so far discovered in the state. The locality was thirty miles west of Meeker, on the White river, near its junction with the Piceance creek. There I saw on the edge of a great hollow basin that had been excavated by erosion out of a broad anticlinal or arched table-land, two powerful springs which had been exploited to a depth of 500 feet. During the work, one of the springs caught fire, and a column of flame, sixty feet in hight and twelve feet in diameter, shot up into the heavens, illuminating the surrounding country for many miles, till it gradually subsided owing to the pressure of water, after destroying the machinery, severely burning the operator, and calcining the ground for several yards around the orifice. The site of this spring is at present occupied by a pond, up through which several jets of gas bubble fiercely.

The other spring, a few hundred yards distant, was also exploited to some depth, and, owing to business matters, abandoned and the tubing drawn out. This spring I also found surrounded by a circular pond twelve feet in diameter. Here the water was in a seething, violent state of agitation, churning round and

round the central orifice, from which great bubbles of gas arose, elevating the surface of the water a foot or more above its level, reminding one very much of certain stages in a geyser eruption. A strong petroleum smell was emitted. We ignited the gas from a safe distance and a column of flame sending out an intense heat, covered the entire surface of the pond and rose to a hight of about six feet above it. We watched it for a while and left it still burning. It is evident there are large bodies of gas in this region, as shown by the two wells, which have been pouring forth volumes of their incense for over a year to waste on the sage brush desert.

Again about two miles from this up the course of the Piceance creek we found an alkali pond with numerous gas jets bubbling up, which ignited with a match and burnt for a few seconds until overcome by water. Professor Sadtler tells me that a well has been discovered on Bussard creek, twenty-five miles air line southwest from Glenwood and about the same distance west from Aspen, which, on digging, poured forth such volumes of gas that the workmen were unable to continue. It is evident that there are large bodies of gas in this region, as shown by the wells which I have described. It is certain, then, that natural gas exists in Colorado.

What might be done with this if it were within reach of some large city like Denver? What manufactories of glass and other works might be run by this cheapest and purest of fuels? Not to mention the illumination of our streets. If the mountain wont go to Mahomet, Mahomet must go to the mountain; and it may be that commercial men may see the wisdom of establishing their manufactories within reasonable distance of these powerful springs.

PETROLEUM.

There is a close chemical relation between natural gas, asphalt and petroleum. They are all hydro-carbons, and are convertible into one another, hence, where one of these substances is found, it is not unlikely to find the others, so there is a reasonable prospect that this White River region, abounding in its natural gas and asphaltum, may some day be found to produce petroleum also. At present our oil production is confined to the small field at Florence in the vicinity of Canon City.

THE FLORENCE OIL FIELD.

Oil was discovered first in Fremont county on Oil or Four-mile

creek, four miles east of Canon City, where it makes its appearance on the surface of the water of the creek. Rumor has it that it was known for years to the Indians, who used it for medicinal purposes. In 1861 Mr. A. M. Cassidy, who was the pioneer in the development of oil in Colorado, erected a small still on the bank of this creek, sank five or six wells in the neighborhood, getting from the entire development about three barrels of crude oil a day, which he refined and sold in Canon City, Pueblo and Denver, at prices ranging from $1 to $5 per gallon. From this small beginning the present industry has evolved.

This field now supplies every gallon of refined oil used west of the Kansas and Nebraska line, including all states and territories to the Pacific coast.

The present total consumption of refined oil in the territory tributary to the Florence oil fields is 4,500,000 gallons per annum, representing in value to the producers about $300,000.

There have been in all about sixty-five wells drilled in this field, with a record of about forty-five producers. Of these there are now about twenty-five wells being pumped. The remaining twenty have gone dry. The average production per day of these wells is forty barrels, or a total of 1,000 barrels daily.

The territory is what is called an uncertain one; there is no guide by which producers can be governed. Oil has been found in depths from 1,000 to 1,800 feet. The drilling has developed the fact that there is a body of shale 3,000 feet thick at least.

Seven miles northwest of Florence, on Oil creek, and back of the penitentiary at Canon City, ten miles west and north of Florence, the outcrop shows oil-bearing sandrock. This sandrock is the supposed original oil receptacle from which the oil has, by pressure, been forced up into the shale above.

The character of the drilling is fairly good, the shale being soft and easily penetrated, but owing to frequent caving, necessitates a knowledge of the territory by the drillers.

The character of the oil is what is termed a heavy petroleum, of a greenish cast of color, and weighing about 32 degrees. The amount of illuminating oil produced from the crude is 33⅓ per cent. The residual or refuse oil is used for lubricating and fuel.

The life of the wells is about two years. The territory marked out and supposed to be oil bearing, is about sixty thousand acres.

Evidences of the existence of oil are to be found in Conejos, Archuleta, Rio Blanco, and Routt counties.

It oozes from the rocks near Morrison, and signs of it are said to have been found at Littleton, and nine miles north of Denver. None of these fields, however, have been sufficiently developed to establish their commercial value.

The oil business of the State of Colorado may in time be equal in importance to our State, that it is to the States of Pennsylvania and Ohio. There are undoubtedly undiscovered fields in the various portions of the state that in time will become available.

SUMMARY AND CONCLUSIONS.

From what we have said we conclude that as regards coal we have inexhaustible fields of it on both sides of the range.

That the fields on the western slope are the largest and most important in quantity and quality.

That the northeastern field on the northeast side of the range carries an excellent ordinary and cheap fuel in its non-coking lignitic coal.

That the "lignitic" type of coal constitutes only a small fraction of our coals, the bulk throughout the state being bituminous.

That the southeastern or Raton field, from Canon City to Trinidad, carries a bituminous coal, one-half the area being coking, the remainder domestic.

That the southwestern or La Plata field across the range, is of much the same character, producing both domestic, bituminous and coking coal.

That the northwestern or great Grand River field bears the greatest varieties of coal—bituminous, coking, some anthracite, the bulk of it being domestic non-coking coal.

That there are still large areas of coal fields but little explored or developed.

That the bulk of our coal is a first-class bituminous domestic coal.

That there are considerable areas of coking coal, producing coke equal to Connellsville, Pa.

That the areas of anthracite are limited.

That we have abundance of excellent coal of various kinds, easily accessible and easily worked, and thus of necessity, fuel in Colorado is cheap.

That the total area of Colorado coal fields is 18,100 square miles.

That our coals are the equal in quantity and quality to those of any State in the Union.

That we stand fifth at present in the rank of coal-producing States, and that there is a greater future before us. That our coal resources are inexhaustible and will outlive our precious metal resources.

That as regards *Natural Gas* we have indications of it in several parts of the state, but at present the only localities where it appears to be in commercial quantities, are on White river and Buzzard creek in the northwestern district of Colorado.

That as regards *Petroleum* there are also indications of it in several parts of the state, but the only productive field is at present located near Canon City, and that the prospects of our industry in this commodity are quite as promising as were those of the early days of Pennsylvania and Ohio.

PLEISTOCENE OF THE WINNIPEG BASIN.

By J. B. Tyrrell, M. A.,Ottawa, of the Canadian Geological Survey. *

During the past two summers the writer has been engaged in examining the shores of lakes Winnipeg, Winnipegosis and Manitoba, and at the present time when so much interest is being taken in the occurrence of former glacial lakes, a few notes on the Pleistocene beds of the Winnipeg basin may not be entirely out of place, in advance of a more detailed report to the Canadian Geological Survey.

The basin of lake Winnipeg itself lies along the western face of the Archæan continental nucleus, the eastern shore being composed of gneiss, granite, altered quartz-porphyry, micaceous and hornblende schist, cericite schist, &c., while the salient points of its western shore are chiefly composed of limestone, ranging from the age of the Trenton to that of the Hudson River or Niagara. Beneath the Trenton limestone is a thickness of one hundred or more feet of soft and almost incoherent Chazy sandstone, and it is from the area formerly covered by this sandstone that a considerable portion of the bed of the lake would appear to have been excavated. Between the salient limestone points, the west shore is chiefly formed of drift deposits.

Lake Winnipegosis has a somewhat similar character, the more northern portion of its east shore being composed of low lying Silurian dolomite dipping slightly towards the lake, while the west shore is composed of drift or occasional cliffs of Devonian limestone.

---

*(Published with the permission of the Director.)

Lake Manitoba is almost entirely enclosed by drift deposits.

From the western side of these two latter lakes a gently rising plain reaches to the foot of the Riding, Duck, and Porcupine mountains.

South of the area of the lakes a plain, generally thickly covered with alluvium, stretches into Minnesota and Dakota.

The escarpment of the Pembina, Riding, Duck, Porcupine, etc., mountains may be conveniently designated the "Manitoba escarpment," and the beds of which it is composed are, as far as is at present known, of Cretaceous age. At the close of the Cretaceous Period these beds, which now rise in places to a hight of 1,700 or 1,800 feet above lake Winnipeg, must have extended a long distance farther east, but with the advent of the Tertiary Epoch, a period of elevation and denudation set in and continued without intermission to the close of the Pliocene. During this period the great north and south valley was formed, on the western side of which now rises the Manitoba escarpment, together with the afferent valleys of the Valley, Swan and the Red Deer rivers.

The history of this region during the first Glacial period is not at all clear, but the second Glacial period furnishes us with an abundant record, from which its story may be easily read.

Let us examine separately, but briefly, the different pages of this record, beginning with that on

Striation.

At the north end of lake Winnipeg the glaciation averages S. 2° W., or nearly parallel to the shore, from William river to the mouth of the Saskatchewan. On Cedar lake, on its eastern side, the striation is S. 18° W., making straight for the ridge north of lake Winnipegosis, while on its western side, near the mouth of the Saskatchewan, the glacial striæ bear S. 39° W. On lake Winnipegosis the striæ at its northeastern angle bear S. 23° W., while a little farther down the east shore they have turned to S. 9° W. Around the south end of the same lake they bear S. 2°–13° E.; in Dawson Bay S. 42°–58° W.; in Swan lake S. 48°–53° W.; in Red Deer river S. 68°–78° W. These three latter courses show a set of the glacier towards the great valleys of the Swan and Red Deer rivers; while those on the south and east sides of lake Winnipegosis indicate a movement parallel to the face of the escarpment.

In the northwestern arm of lake Manitoba the striæ are bear-

ing southward, while on the eastern side of the lake, near Steep Rock point, their direction is S. 8°–13° E. The granite islands in lake St. Martin are well striated in a direction S. 33° E. These observations all show that the glacier moved southward in the great Winnipeg valley, the direction of movement being clearly proved by the characters of many of the exposed and striated rock-surfaces.

On the east side of lake Winnipeg, the general direction of glaciation has already been recorded by Dr. Bell as trending more or less directly out into the lake. Some instances of the occurrence of two sets of striæ have however lately been observed that would appear to indicate an earlier glacial movement more nearly parallel to the shore, though the earlier striæ have been almost entirely obliterated by the later.

On Swampy island the general direction of striation is S. 52° W., while another set of striæ was found to occur under a mass of pebbles and boulders bearing S. 13° E. Mr. Panton has already recorded striæ running in a similar direction on Black Bear island forty miles further south. [1]

In lake Winnipegosis, where many striæ have been observed, the islands and points of till and boulders lie in the direction of glaciation, and applying the same rule to the palæozoic area of lake Winnepeg, where much of the country has not yet been examined, the direction of glacier motion is seen to swing southward from the east shore, till at the mouth of the St. Martin (Little Saskatchewan) and Fisher rivers it would appear to have been about due south.

South of the lacustral area in Manitoba, striæ have been recorded by Messrs. Panton[2] and Upham from Stonewall, Stony mountain and Little Stony mountain bearing S. 20°–25° E., [3] and on the Assiniboine river in Sec. 23, Tp. 9, R. 10, striæ were lately observed by the writer on the surface of Niobrara marlite bearing S. 38° E. Farther south, within the United States, striæ made by a continuation of the same great glacier have been recorded by Pres. T. C. Chamberlin down to the northern boundary

[1] Notes on the Geology of some islands in lake Winnipeg by J. Hoyles Panton, M. A., Hist. and Sci. Sec. Man. Trans. 20, 1886, p. 6.

[2] Gleanings from Outcrops of Silurian Strata in the Redriver valley by J. Hoyles Panton, M. A., Man. Hist. and Sci. Soc. Trans. 15, 1884, p. 7.

[3] Report of Exploration of the Glacial lake Agassiz in Manitoba by Warren Upham. Can. Geol. Surv. Ann. Rep. Vol. IV, part E, p. 115.

of Minnesota, beyond which, in the vicinity of Des Moines, Iowa, was found the outermost terminal moraine of the glacier.[1]

These numerous observations of distinct and characteristic glacial striæ clearly show that a great glacier, or lobe of the Laurentide glacier, which for convenience may be called the Manitoba glacial lobe, or glacier, moved south-southeastward across the lacustral plains of Manitoba, along the valley of Red river to the hight of land, and onward to near Des Moines, Iowa, sending off branches up the valleys of Swan and Red Deer rivers. The total length of the Manitoba glacial lobe, therefore, from the north end of lake Winnipeg to its extreme southern limit in Iowa would be about 850 miles.

Moraines.

The highest moraines at present known in northern Manitoba are those capping the summits of portions of the Duck and Riding mountains with altitudes of 2,500, 2,700 feet above the sea, or 1,800 to 2,000 feet above the surface of lake Winnipeg. A good example of this moraine is seen on the northeastern portion of Duck mountain, where it forms a barren, rugged district with conical hills often rising to a hight of 200 feet. These hills are composed entirely of drift so thickly studded with Archæan boulders, that their crests have much the appearance of the rounded knobs of granite and gneiss east of lake Winnipeg, the likeness being made more striking by a thin and stunted growth of pine. When the writer passed over this region he had been preceded a year or two before by a forest fire, which had burnt over most of the hills and left them strewn with blackened sticks about the size of fence rails, lying irregularly over the mass of boulders. Very few deciduous plants had grown up to cover the surface, and there was nothing to veil the absolute desolation of the scene.

No definite and well marked moraine has been traced along the face of the Manitoba escarpment below those just mentioned, but distinct moraines occur at elevations of about 1,300 and 1,500 feet respectively in the valleys of the Swan and Valley rivers, which may represent the terminal moraines of subsidiary lobes of the Manitoba glacier.

For a long distance eastward from the escarpment no morainic hills are known, but it is not impossible that they may exist in

[1] Terminal Moraine of the Second Glacial Epoch, by Thomas C. Chamberlin. 3d Ann. Rep. U. S. Geol. Surv. map, opp. p. 382.

places, for most of the country between lakes Manitoba and Winnipegosis and lake Winnipeg is yet entirely unexplored. However at many places on the shores of lake Manitoba, especially towards its northern end, and on the shores and islands of lake Winnipegosis south of Birch island transported boulders are scattered in great abundance, or heaped in high boulder-walls. The north side of the high and even ridge between lake Winnipegosis and Cedar lake, and the south shore of this latter lake, are also composed to a considerable extent of erratics. It is not improbable, therefore, that these boulder-strewn tracks may represent periods of cessation in the retreat of the glacier, but the morainic debris was dropped into lake Agassiz, and scattered more or less thickly over its floor.

On the shores and islands of lake Winnipeg a distinct moraine has just been recognized. It forms the high land on the eastern side of the lake between the mouth of Brokenhead river and Elk island; crosses Black island near its northeastern extremity as an irregular, knolly ridge with a summit one hundred feet above the water; thence skirts the eastern margin of the lake, touching it in places, and was again recognized at Plunkett and Swampy islands, being there composed of an aggregation of boulders of Trenton and Archæan rocks. Many of the islands to the south of these two last mentioned are also probably morainic, but they have not yet been examined.

North of Swampy island this moraine has not been followed, and as it was doubtless deposited in a considerable depth of water, the material falling from the face of the glacier was probably scattered over a considerably area. It is possible, however, that George's island may be formed by it, and Eagle island, near the northwest extremity of the lake, is clearly morainic.

Shore Lines.

Ancient shore lines occur throughout the district from a hight of 1,440 feet above the sea on north Pine creek on the east face of the Duck mountain to about 750 feet above the sea around the margin of lake Winnipeg. In their southern extension, these ridges have already been described and classified by Mr. Warren Upham in his description of lake Agassiz.

In the lacustral region they have been followed by the writer most continuously along the face of the Duck mountain where they form long, unbroken ridges of gravel or sand from fifty to one

hundred and fifty feet in width. The pebbles in the gravel are nowhere large, not having been met with as large as a hen's egg, and on the face of the Duck mountain they are beautifully assorted, becoming finer as the ridges are followed north from Valley river. At Drifting river they are about as large as pigeons' eggs, at Fork river about as large as peas. At Duck river the ridges are composed of sand. This gradual diminution of the size of the pebbles was traced especially in the ridges that at the Valley river have elevations of 1,135 and 1,084 feet respectively. Farther north, along the face of the Porcupine mountains, the ridges wherever examined were composed of sand and fine gravel.

Between the Manitoba escarpment and the lakes ancient beaches have been found in but few places, and in some of these they appeared to be discontinuous while in others they were not followed. At one of these places on Pine creek a well-defined ridge of gravel is determined by the old location of the Canadian Pacific Railway to have an elevation of 960 feet. None of the beach ridges, however, are stronger than those around the adjoining lakes at the present day, and some spits and bars on the shores of these lakes are much larger than any of those seen around the basin of the extended glacial lakes.

One of the most interesting monuments of ancient shore phenomina in the whole district is Kettle hill, on the south side of Swan lake. This lake has an estimated elevation of twenty-seven feet above lake Winnipegosis or 855 feet above the sea, and the hill which appears to have been largely composed of Dakota sandstone rises 275 feet above it. On the face of this hill are five distinct terraces representing six different shore lines at elevations of 920, 955, 995, 1,015, 1,070 feet above the sea, those at 955, 995 and 1,070 being most strongly marked, the last being the most distinct.

On the north side of lake Winnipegosis the eastern Mossy portage is a gravel ridge rising at its extreme summit 93 feet above the surface of that lake, or 921 feet above the sea. Just to the southward, the north shore of the lake rises to the top of the portage by three distinct steps 27, 63 and 93 feet in hight. The last is the summit of the portage ridge, and the first is the summit of another well marked gravel ridge behind which is occasionally a trough ten feet deep, marking a shore line about 15 feet above the present hight of the lake, or 843 above the sea. This shore

ine is also well seen at Point Brabant and other places along the east side of the lake. When the water stood at this level lakes Manitoba and Winnipegosis were joined across the Meadow portage, and the beach is therefore to be looked for around the former lake. It is probably represented by the ridge in the grove behind Manitoba House, though the exact hight of this ridge was not determined. On the line of the tramway at the Grand rapids on the Saskatchewan river four well defined ridges of rounded gravel occur at the hight of 140, 95, 90 and 80 feet above lake Winnipeg or 850, 805, 800 and 790 feet above the sea.

At Ox Head, near the northeastern extremity of Black island, an ancient beach is very conspicuous at about forty feet above the water. On the south side of the island the beach is marked by a line of sand dunes, and on the north side a sandy terrace rises gently to a hight of forty feet and ends abruptly at the foot of a steep slope thickly strewn with boulders. On ascending this slope the land is found to rise to a hight of 100 feet above the lake and its summit to consist of an irregular aggregation of knolls thickly strewn with large boulders of gneiss, very few or none being derived from the immediately adjoining and underlying Keewatin schists. This ridge is the summit of the Black island moraine which would seem to have been dropped here when the higher parts of the island were above the surface of lake Agassiz, as there is no sign of water action on the moraine above the line of the forty-foot beach. It is possible that the moraine may have been deposited about the water level, and that the water afterwards rapidly receded to a height of forty feet above the present lake.

Delta deposits occur at the mouths of all the wide valleys opening into the west side of the lacustral plain, but unlike the delta of the Assiniboine they nowhere extend eastward beyond the general line of trend of the escarpment.

Alluvium.

The Red River valley south of north latitude 50° is thickly covered with alluvium, evidently thicker near the river than farther away from it, its thickness at Rosenfield being 125 feet, while at Morden, twenty-four miles farther west, and just at the foot of the Pembina escarpment its thickness is only 15 feet.

North of latitude 50° a soft blue alluvial clay overlies the Archæan rocks along the whole of the east shore of lake Winnipeg beyond Winnipeg river, ranging in depth from 5 to 30 feet.

It is generally more or less distinctly stratified and at its base in many places contains transported boulders. It also forms the north shore of the lake as far westward as the base of the sand spit that bounds Limestone bay on the south. The western side of the lake has not yet been sufficiently examined to say to what extent the older deposits are there covered with alluvium.

In the western portion of the lacustral basin Prof. Hind remarked as long ago as 1859, speaking of the "Big Ridge of the Assiniboine" which has been called by Mr. Upham the Ossowa beach, that "between this ridge and the Assiniboine the land is eminently rich and fertile; beyond the ridge north, it is described by the half-breeds as wooded, sandy and poor."* Around lake Manitoba and Winnpegosis, there is comparatively little alluvium, the country in many places being immediately underlain by till.

Lake Agassiz.

In the absence of any evidence of a land barrier to the north and east sufficiently high to hold back the waters of the lake whose receding shore lines are marked by the beaches mentioned above, Mr. Upham has suggested that the water was held between the edge of the receding glacier of the Winnipeg valley and the Manitoba escarpment, and to this body of water he has given the name lake Agassiz. As to the extent of this lake south of the present southern shores of lakes Manitoba and Winnipeg, nothing can be added at present to what is given by Mr. Upham in his recent report to the Canadian Geological Survey. Of the lacustral region very little evidence was at hand, and the generalizations from that evidence were clearly of a preliminary character.

Instead of assuming that lake Agassiz at any time covered an area of 110,000 square miles, as stated by Mr. Upham, let us consider the hypothesis that it was never at any time of enormous size, but rather that it was a belt of water, say as wide as lake Manitoba now is, lying along the foot or edge of the glacier and quite possibly with a large expansion towards the south. Under this hypothesis the lacustral area was covered with the Manitoba glacier while all the more elevated beaches were being formed, and how far south this glacial lobe extended at any particular time it is impossible to say, since its foot was washed by the waves of the lake, and the coarser morainic material that dropped

*Papers relative to the exploration of the country between lake Superior and the Red river settlement, page 106, folio London, Gov., 1859.

to the bottom was afterwards covered with a sheet of fine alluvium, just as has occurred in the deposition of the alluvial clay on the east shore of lake Winnipeg.

While the face of the glacier was not far removed from the Manitoba escarpment, and when in places the highest beaches were in process of formation a sand delta was deposited in front of the mouth of Short creek in the depression now drained by Valley river. While the sand plain was being formed here the fine material brought down by the river would, under ordinary conditions, have been carried out into the lake and have formed a fringe of alluvial clay which would now be found covering the lower country. This does not appear to have been the case however, for but a few miles from the front of the sand plain of the delta, gravel ridges rest directly, or almost directly, on the till, and it is probable that the finer alluvium was spread out for a considerable distance north and south from the mouth of the old delta-forming river.

As the glacier, in its intermittent recession, drew back from the escarpment, the lake followed it, dropping more or less suddenly from beach to beach, and probably being drained northwestward as well as southward. A northerly current in the lake or a contraction in its width is clearly evidenced on the face of the Duck mountain by the gradually diminishing size of the pebbles of which the beaches are composed as they are followed towards the Swan river valley from the Riding mountain; the general small size of the pebbles is also remarkable as larger pebbles and boulders are found in the underlying till. The absence or scarcity of boulders on these beaches has already been recorded by Mr. Upham and the writer, and has been adduced as evidence that lake Agassiz did not freeze over, but even then it is difficult to conceive why masses of ice laden with boulders should not be thrown on the shore. Dr. Dawson has suggested that the water was at no time sufficiently deep to float icebergs, and it is possible that this may be one reason for the difference between these old ridges and the present beaches of lake Winnipeg. The beaches are almost unbroken, and are rarely more than ten or fifteen feet in hight. These facts lead to the supposition that they had not been acted on by waves such as would be generated on a lake with an area of more than 100,000 square miles, for on the shores of any of the three adjoining lakes of comparatively small dimensions, higher beaches composed of larger pebbles are of com-

mon occurrence and are more or less constantly broken by the waves. When the Manitoba lobe retired to the north and east of the country now partially occupied by lakes Manitoba and Winnipegosis leaving boulders thickly scattered over the surface, the water stood at least eighty or ninety feet above the present level of lake Winnipegosis, but it does not appear to have stood at this height for any great length of time, since, in the northern portion of the region especially, little or no alluvium has been deposited over the till and paleozoic rocks. In receding from this hight the water has left two moderately well marked beaches, that fifteen or twenty feet above lake Winnipegosis being possibly represented farther south by the Ossowa beach, and northeast by the highest beach at the Grand Rapids. During this and the succeeding period when the waters stood at the level of the triple beach at Grand Rapids, from 80 to 95 feet above lake Winnipeg, the ice foot appears to have extended down the middle of lake Winnipeg, and it was towards the end of this latter period that the moraine was formed across the summit of Black island. The ice then receded to the higher land east of lake Winnipeg, and there is no farther necessity for assuming an ice-barrier in that direction.

The next time that the water came to a standstill it would seem to have been about forty feet above the present level of the lake, and the channel of drainage was probably through a wide valley extending northward from Limestone bay.

It was during this last recession that the smooth glaciated surface of the archæn gneiss and schists on the eastern side of the Winnipeg basin was strewn with boulders fallen from the face of the glacier, and when the glacier had retired these boulders were covered by and imbedded in a soft blue clay, in which have since been formed many thin disc-like calcareous concretious. This clay doubtless consists of the finer material brought down by the glacier, and spread over the adjoining lake floor by the action of the water. As far as seen, it everywhere lies on the smooth glaciated surface of the Archæan gneiss and schist, and is not underlain by till.

From the above considerations, which have been very briefly stated, it would appear probable that lake Agassiz was not at any time of very vast extent, but rather that it was a margin of water of varying width lying along the face of a great glacier which was retiring down a gradually declining plain.

ON A LEAF-BEARING TERRANE IN THE LOUP FORK.

By F. W. Cragin, Topeka, Kansas.

An interesting leaf-bearing terrane occurs in the Loup Fork Tertiary, on branches of the North Canadian, or Beaver creek, in the "Public Lands." Its outcrops, so far as now known, are on the south side of the stream. The locality is near Alpine, and is, by wagon-road, between thirty-five and forty miles southwest of Englewood, Kansas, the nearest railroad point. It has been known to the writer as a leaf-bearing locality since the spring of 1888, from an impression of a large *Platanus* leaf preserved on a block of fine, white, chalk-like rock and which was presented to him by Mr. Henry Fares, with the statement that the locality abounded in fossil leaves and that fish remains occurred in the same deposits.

In texture, this rock resembles certain fine, white phases of the Niobrara chalk of western Kansas, being quite free from the sand which, of a fine sort and in small proportion at least, is an almost invariable constituent of the lime-like variety of the Loup Fork rock known in western Kansas under the names of "native lime," "poor man's plaster,"* "gypsum," and "gyp." A sample submitted to an eastern zoölogist, for microscopical examination, was reported to contain "coccoliths and rhabdoliths." This report was unfortunately incorrect; but on the strength of it, the writer provisionally referred the leaf-bearing chalk-marl of Alpine† to the Niobrara Cretaceous, regarding it as an example of chalk formed near land, and hence probably in water of moderate depth.

In June 1890, the writer was for the first time able to visit the locality from which the leaf had been taken, and found that the supposed chalk was a *lacustrine marl*, yielding *Planorbis*, *Sphærium*, crushed specimens of an *Anodonta* or *Unio*, and the scales and spines of percoid fishes.

The slopes of the Beaver, in the vicinity of Alpine, are formed chiefly of Tertiary deposits, immediately underlaid by gypsiferous red-beds, of supposed Triassic age, which crop out to the north-eastward in the Cottonwood cañon and at the mouth of Crooked creek, and again to the westward and southwestward on the Beaver and on Clear creek, near Beaver City, the Clear creek

*This name is applied also to massive gypsum in Barber county, Kan.
†Bulletin Washb. Coll. Lab. Nat. Hist., Vol. 2, p. 67.

outcrops bearing a thick bed of massive gypsum. Loup Fork mortar-ledges, bearing teeth of *Hippotherium speciosum*, etc., outcrop at many places, and Quarternary deposits, yielding remains of *Mastodon*, occur along the larger streams and draws. Sand-hills, produced chiefly by the decomposition of the Loup Fork mortar-rock and the drifting of its less soluble constituents, occupy a lower portion of the slope on the north side of the Beaver.

The leaf-bearing marl has a number of outcrops south and southwest of Alpine. That especially examined is a rather steeply inclined bed, closely related stratigraphically to a ledge of ordinary Loup Fork mortar which yields teeth of *Hippotherium*. It is more or less stratified to laminated parallel with its inclined upper surface. Lithologically it is a white calcareous to siliceo-calcareous rock, composed of impalpably fine substance, and more or less indurated, according to the proportion of chemically combined silica. The purest parts of this bed have the earthy fracture, soft smooth feel, easily finger-smoothed surface, and general physical appearance of chalk. Other parts have a stony hardness and the texture of fine-grained limestone. Portions of neighboring outcrops are decidedly siliceous, resembling in texture lithographic limestone, or even chert. The harder varieties, in keeping with their highly siliceous character, break with conchoidal fracture. In the softer, and sometimes in rather hard varieties of the marl occur chert-like concretions, the larger of which reach a diameter of two or three feet. These are usually sharp-outlined oblate spheroids of perfect symmetry, though sometimes irregular. They break with conchoidal fracture into exceedingly sharp-edged segments, the fresh surfaces of which have the color of milk-trimmed coffee, bleaching to white under the weather.

Attempts at using the rock for building purposes, by selecting intermediate varieties, have proved unsuccessful. The softer varieties crumble ; the harder are too brittle, cracking into conchoidal-faced segments upon prolonged exposure to the elements. There occurs, however, in this district, still another phase of rock of the Loup Fork which is more like ordinary stone in its relation to practical purposes. This is a compact siliceo-calcareous breccia, almost entirely composed of broken shells and siliceous shell-casts of a species of *Planorbis* ; it answers fairly for well-curbing, foundations, etc.

Certain ferruginous beds also were seen in this district, and are

presumably referable to the Loup Fork; but these were not examined closely.

In the chalk-marl proper, and in the harder and softer phases alike, occur dicotyledonous leaves, diatoms, fish-remains, and molluscan shells. In the midst of the best-observed outcrop, is a local parting or stratum of laminated chocolate-colored shale, the relation of whose laminæ to those of the chalk-marl proves it to be a genuine member of the latter, and not an intrusive deposit of later date; and in this shale, the writer found, together with molluscan remains similar to those in the chalk-marl proper, and two undetermined genera of aquatic or marsh-plants, the proximal end of an ulno-radius which is apparently referable to one of the *Camelidæ*, and in any event, to an animal as large as *Procamelus occidentalis*, and which had the distal portion of the ulna and radius completely coössified. This bone has the same chocolate color as is seen in the shale itself, and a tooth of *Hippotherium speciosum*, which was picked up in a gully in the marl-bed, shows a state of preservation and color so similar that it can only have come from the same shale. The ulno-radius itself, however, settles the age of the leaf-bearing marl. Whatever be the genus or species, it indicates an ungulate limb of such a kind and degree of specialization as, taken in connection with the size, would be inconsistent with its reference to any epoch earlier than the Loup Fork. That the marl is not later than the Loup Fork, its stratigraphic relation to the associated Loup Fork Hippotherium-bearing mortar clearly shows.

The white marl itself contains a variety of leaves which are, in part, such as it is a surprise to find associated with late Tertiary mammalian remains, and which promise to shed some light on the age of certain Rocky Mountain leaf-bearing horizons. The forms of leaves thus far collected from the Alpine chalk-marls are identified as follows:

1—*Platanus sp. indet.*, 2—*Platanus aceroides* Göpp.
3—*Salix angustata* Al. Br., 4—*Sapindus sp. indet.*,
5—*Populus greviopsis* Ward, 6—(?) *Populus sp. indet.*
7—*Credneria daturæfolia* Ward.

Some of the leaf-impressions in this marl retain more or less of the lignitized woody material of the leaf, giving a black color to those in which a considerable amount of carbonaceous substance is thus retained.

No. 1 is a very large leaf with obtuse teeth ; it measures eight and a half inches in breadth. No. 5 might be referred to *Greviopsis populifolia* Ward, as well as to the species to which it is here assigned ; and, indeed, the generic and specific distinctness of these forms seems doubtful. No. 6 is an ovate-cuneate form which bears no small resemblance to two somewhat larger leaves in the museum of Washburn College from alleged Laramie beds at Trinidad, Colorado. The identity of No. 7 with the species which Ward has described from the white marl bed forming the summit of the "Fort Union" beds of Seven-Mile creek, Montana, under the name of *Credneria daturæfolia*, admits of no question, whatever doubt may exist as to the propriety of referring the species to the genus *Credneria*.

The occurrence of this species in the Loup Fork Tertiary is of unusual interest. In Volume I. of the Fortieth Parallel Reports, published in 1878, King wrote, "I apprehend that the plant horizon at Fort Union will be found to be nothing but the northward extension of the White River Miocene." Whatever be the age of the lower part of the Seven-Mile creek beds, the occurrence of *Credneria daturæfolia* in the Loup Fork indicates not only that the white marl cliff which forms the summits of those beds is probably referable to an epoch not earlier than that indicated by King, but that it may well be reëxamined with a view to its possible referability to the Loup Fork.

A curious palæontological feature of the Alpine chalk-marls is the apparent evidence of a certain degree of brackishness in the waters of the great lake.

Following are the names of the diatoms identified by Rev. Francis Wolle, of Bethlehem, Pa., in a sample of the marls sent him, together with his notes on the habitats:

Cymbella cistula Hempr.—More frequently fresh-water than brackish.
Navicula peregrina.—Brackish water.
" *tenella* Breb. } These two may be forms of *Schizonema*;
" *lanceolata* Ktz. } hence marine.
Coscinodiscus woodwardi Eilenstein.—This is the most decidely marine.
Melosira granulata (Ehr.) Ralfs.—Brackish or marine water.

The Loup Fork calcareous sandstone has been universally called a fresh-water deposit. This view is no doubt essentially correct; yet the influence of the gypsiferous and saliferous "red-beds" floor of the Indian Territory district of the lake may have imparted locally a somewhat brackish character to the lake-water.

THE OZARK SERIES.

By G. C. BROADHEAD, Columbia, Mo.

In the GEOLOGIST for January and September 1889, the Ozark plateau was discussed by myself as to its elevation and extent.

In the Missouri geological report, 1855, Prof. G. C. Swallow published a vertical section of palæozoic rocks, which has suffered but few corrections. As corrected, it is about as follows:

Upper Carboniferous	2000	feet
Lower Carboniferous to base of Burlington	1145	"
Chouteau group	205	"
Devonian	125	"
Upper Silurian	175	"
Hudson River group	165	"
Tienton and Black River limestones	360	"
MAGNESIAN LIMESTONE SERIES.		
First Magnesian limestone	190	"
First or Saccharoidal sandstone	125	"
Second Magnesian limestone	230	"
Second sandstone	70	"
Third Magnesian limestone	350	"
Third sandstone	50	"
Fourth Magnesian limestone	300	"

This series of magnesian limestones is known in Missouri by its numbers; the "First" is rarely found in central-southern Missouri, excepting on the most elevated points, but it is better developed in the counties bordering the Missouri river, occurring as a gray or buff or drab limestone, sometimes oölitic as near Horiñe in Jefferson county, or abounding in *Cythere sublævis*, as at Pacific, in Franklin county. The First, or Saccharoidal sandstone reaches its greatest thickness near Augusta, St. Charles county, where it is 133 feet thick. A corresponding thickness was recorded in the boring at the Insane Asylum, St. Louis. Its upper part is white and pure silica, its lower part often colored brown. It is the equivalent of the St. Peter's sandstone. The only evidence of organic remains found in it is a large *Orthoceras*, about 8 inches in diameter.

This sandstone is valuable as a material for glass-making, and the glass-works at Crystal City, in Jefferson county, are located at a favorable outcrop. The Second Magnesian limestone is well exposed at Jefferson City, and includes all the strata in sight at that city. The lower beds are thick and cellular, the small cells filled with a white powder, or else empty. Above these there is a good deal of chert occurring mostly in a concretionary form, together with some shale, and earthy drab-colored magnesian limestone beds, locally called "cotton rock." But a small per cent. of this

is suitable for building. Fossils are not abundant. Those found are a *Lingula* (like *L. prima* Hall) an *Ophileta*, and *Pleurotomaria*. At the base of the hill at Hermann, a trilobite (probably *Conocephalites*), an *Orthis*, &c., were obtained.

The Second sandstone occupies the tops of the hills in Madison, Washington, Reynolds, and some other counties, and is apparently replaced by certain chert beds in those counties. This sandstone is coarser than the First sandstone, and is often slightly colored with iron, and is often a firm, solid rock, useful for building purposes. The Third Magnesian limestone occupies the base of nearly all the hills of southern Missouri, sometimes reaching to the hill tops. It occurs chiefly in thick beds of coarse, gray dolomites, or finer textured flesh-colored layers, the latter sometimes as much as 20 feet thick between the bedding planes. The coarse gray dolomites often disintegate and weather into rough surfaces, and at the lead mines decompose into dolomitic sand.

The Third sandstone was recognized by Prof. Swallow, on the Osage and Niaugua rivers, in Camden and Dallas counties.

A part of this series may be referred to Prof. Dana's Canadian period.

The First Magnesian limestone lying below the Trenton group, may be Lower Silurian, and some have considered it to be of the age of the Chazy; in the absence of fossils it is not easy to assign it to its proper place. The series below, including to the base of Second sandstone, and probably part of the Third Magnesian limestone, may be considered of equal age with the Calciferous of the New York system. The Lower part of the Third Magnesian limestone may probably be of the age of the Potsdam, and the other strata below seem certainly to be of Potsdam age. The Second Magnesian limestone and the other series below to the Archæan seem to correspond with the description and position of beds referred to the Upper Cambrian by Mr. C. D. Walcott. So, whatever may be the true geological position of this series of rocks, they belong to different periods of geologic time. I therefore, for this reason and from the similarity of the composition of the rocks, think best to place them in one series, and call that great series

"THE OZARK SERIES"

Distributed as follows:

First Magnesian limestone.
First or Saccharoidal sandstone—St. Peter's sandstone.
Second Magnesian limestone.

Second sandstone.
Third Magnesian limestone.
Third sandstone.
Fourth Magnesian limestone.

The term Magnesian has been applied to rocks of other ages, and, for that reason, has not been well taken. The term Ozark, is peculiarly well adapted, for it includes rocks that are not only found amid the Ozarks, but are there better developed.

In south-eastern Missouri certain members of the lower part of the series are wanting, and the Third Magnesian limestone is not well separated from a lower limestone which may be the equivalent of the Fourth. The lowest rock near Mine La Motte is a sandstone which, near Fredericktown rests directly upon granite. There are also occasional exposures of a variegated red, purple, buff and drab marble whose position is above the sandstone. Above the marble beds are gritstones and magnesian limestones and dolomites which are the lead-bearing rocks of Madison and St. François counties. These lower limestones contain *Lingulella lamborni* of Meek at several places. If that fossil is of Potsdam age, then these lower limestones and sandstones are of Potsdam age. The marble beds have occasionally furnished beautiful polished slabs of marble. Nearly 35 years ago Mr. Henry Cobb, of St. Louis, had a quarry of it opened near Ironton, in Iron county, and attempted to bring it into notice. He termed it "Ozark" marble, and in deference to him I will still use the name. The series in Iron, Madison, and St. François counties is as follows:

OZARK SERIES.

Second sandstone—on hill-tops with chert..........	125	feet
Third Magnesian limestone with chert and quartz...	225	"
Gritstone and Lingula beds........................	50	"
Ozark Marble beds.................................	25	"
Lower sandstone and conglomerate..................	90	"

The above series rests on Archæan porphyries and granite.

University Columbia, Mo., April, 1891.

SOME RECENT GRAPTOLITIC LITERATURE.

By R. R. GURLEY, U. S. National Museum.

Besides several minor papers* the graptolitic literature of 1890 com-

*De Rouville, Prof. P. G. Note sur le presencè du *Pleurodictyum problematicum* dans le Devonien de Cabrières et sur un nouvel horizon de Graptolites dans le Siluriën de Cabrières: Bull. Geol. Soc. France, XVIII, pp. 196-97 (Notes discovery of an Arěnig fauna).
Dodge, W. W. Some Silurian Graptolites from Northern Maine; Am. Jour. Sci., XL, pp. 153-55 (Notes occurence of the Norman's Kill fauna in Penobscot County).
Nicholson, H. Oliphant. Notes on the discovery of *Trigonograptus ensiformis*, Hall (sp.) and of a variety of *Didymograptus V-fractus* Salter in the Skiddaw slates; Geol. Mag. VII, pp. 340-44 (Describes *D. V-fractus* var. *volucer*, var. nov.).

prises four papers of some length, an abstract of which is attempted in the following pages. As will be seen all are the work of foreign authors.

Ueber das alter d. Sogen Graptolithen-Gesteins mit besonderer Berücksichtigung der in denselben enthaltenen Graptolithen; by Otto Jäkel. Ztschr. d. deutsche geol. Ges., XLI, pp. 653–716 ; Berlin 1890.

The Gestein, the author tells us, belongs unquestionably to the Upper Silurian. The only question is as to its exact horizon within that system. After reviewing the opinions of previous workers he expresses his belief that the Graptolithen-Gestein finds its equivalent in various horizons of the Wenlock Shale.

The Graptolites of the formation are next considered. At the outset (p. 660) the author mentions Barrande's division of the Graptolites into the one-rowed and two-rowed. He further tells us that all true Graptolites are still classified in accordance with this scheme. This statement does not indicate a profound acquaintance with the later graptolitic researches and especially with that masterly series of memoirs which has made Professor Lapworth's name to the present generation of graptolithologists what those of Hall, Barrande and Geinitz were to the preceding. Indeed we have hardly met with another recent paper on this group from which the name of Lapworth is so conspicuously absent. Correlated with this peculiarity is the slight esteem in which the author holds the sicula, which might not inaptly be termed the *organ of Lapworth*, so closely is it associated in the mind of the graptolithologist with his researches. In short, throughout the whole memoir the subject is treated from the standpoint of Nicholson's Monograph of the British Graptolitidæ, a work which represented the high water-mark of the science at the time of its publication (1872) but which, we are sure, its own author would not recommend to Herr Jäkel as a modern text-book on Graptolithology, so great has been the progress of our knowledge during the last eighteen years.

Returning to the text we find that, apparently misled by the fact that *Monograptus*, Geinitz, has obtained currency to the exclusion of *Monoprion*, Barrande, in defiance of, and not in accordance with, the rule of priority, Herr Jäkel tells us that: "The generic name *Monograptus* previously employed by Geinitz has been used by the later authors in place of *Monoprion* of Barrande and in the same sense as the latter."*

We regret to find ourselves as little able to agree with Herr Jäkel's views as to the conditions of life of the Graptolites as we were to admit the correctness of the statements quoted. He discusses at some length the subject mentioned and concludes that the true Graptolites must have been fixed. His reasons for this divergence from what we take to be the consensus of two generations of observers is his inability to under-

* M. Barrande described *Diprion* and *Monoprion* in 1850. In 1852 Dr. Geinitz, remarking that *Diprion* was preoccupied, employed Professor M'Coy's term *Diplograptus* in its place. In this connection he said that *Monoprion* must be changed to *Monograptus* for harmony (*Einklang*). Later the powerful influence of Prof. Lapworth has secured its retention. He gives his reasons for favoring it instead of Barrande's name (which he admits has priority) in his memoir on the Scottish Monograptidæ (Geol. Mag., 1876, III. pp. 310-11). It is probable that *Lomatoceras* (Brown, 1835-7, Leth. Geogn. I, pp. 55-6), should supercede them all.

stand in what way the heavy polypary could have been moved. Wave action being excluded ("the Graptolites were deep-sea dwellers") flotation could only be secured, he argues, through swimming movements of the zooids or by the possession of a hydrostatic apparatus. The possibility of movement by the former means is regarded as very improbable in view of the independence of the cells, their opening upon one side only, and the form of the stem on the other side. No less improbable, he thinks, is the assumption of a hydrostatic apparatus. It is asserted that such could only have been the central disk. Herr Jäkel rejects the possibility of such a view of its function as the cells would necessarily have been directed downwards, a condition which, he tells us, has never been observed in the analogously constructed living colonies.

On the other hand, by assuming these organisms to have been fixed we can, he thinks, form a "simple and natural picture" of the genus *Dictyonema* with the "cell-less net" imbedded in the mud and the cell-bearing branches projecting with the cells directed upward. Possibly this may possess the merit of simplicity, but the fact is that the "cell-less net" has no existence. If Herr Jäkel will consult Brögger's memoir[1] he will find that the branches in Dictyonema are thecaphorous along their whole length; although they may apparently lack thecæ in any portion from unfavorably directed pressure. The central disk is also by Herr Jäkel regarded as mud-imbedded.

The sicula receives little notice. It indeed furnishes opportunity to quote Professor Nicholson's Monograph again to the effect that the radicle (sicula) was present certainly in some and probably in all cases. We are then told that "when this probably shall have been actually made credible through numerous and not as heretofore by 'some cases,' I would ask whether this organ may not be regarded as the foundation of the stem and have served for preliminary imbedding until, the lateral spreading of the 'cell-less root' or a broad disk moored it securely." Considering the overwhelming mass of evidence showing the sicula to be the embryonic stage, so to speak, of the graptolite, it is only necessary to remark that in some genera the sicula is so imbedded in the substance of the polypary that it could not have been stuck in anything.

For his next theory the support of Prof. Hall's authority (under date of 1865) is invoked. This time it is a revival of the view that the Monograptidæ are fragments of compound forms; another defunct hypothesis which, natural enough for the date at which Prof. Hall wrote, lacks the slightest trace of support from later investigations.

We arrive now at the proposed subdivision of the genus *Monograptus*. We are here reminded very strongly of the methods of securing a change of dynasty in vogue in some of the South Sea Islands. When a king becomes aged he is told by his son that he in his turn wishes to mount the throne. The old monarch acquiesces and a funeral procession is formed which escorts him to his grave. Some such custom seems about to be introduced into our midst. With regard to Herr Jäkel's proposition to divide the genus *Monograptus* we have nothing to say. It is not the

[1] Brögger, W. C., 1882. Die silur Etagen 2 & 3, im Kristianiagebiet.

division, but Herr Jäkel's mode of dividing that excites our apprehension. Instead of the customary gemmation we are introduced to a process of nomenclatural fission which we confess is new to us. Its chief characteristic seems to consist in *the entire disappearance of the original genus.* We cannot but pronounce it a most flagrant violation of the rules of nomenclature.

The genus *Pristiograptus* (one of the two unnatural offspring which have thus devoured their parent) is characterized by an axis straight or bowed outward, a free mouth opening formed at the expense of the bevelled upper lip; thecal processes when present are found upon the under lip.

In *Pomatograptus* (gen. n.) on the contrary the axis is straight or curved inward, the mouth opening small under the over arching upper thecal lip.

Herr Jäkel closes his remarks upon classification by the following italicised paragraph:

"*This highly interesting case (the above 'parallel') with many others shows that the one-rowed and more-rowed Graptolites are not systematically separable but are to be classified phylogenetically and naturally from a higher point of view.*"

The description of *Retiolites* which is perhaps the least faulty portion of Herr Jäkel's article terminates the section devoted to Graptolites. At the outset Herr Törnquist[1] feels compelled to except to the author's statement. He says: Little if anything is added to our knowledge of the generic structure beyond the points elucidated by the Swedish paleontologists during the previous decade. We need only mention the author's proposition to classify *Retiolites geinitzianus* along with *Pristograptus* (Monograptus).

Herr Jäkel tells us (p. 666) that after acquainting himself with special literature of the Graptolithen-Gestein he found it impossible to inform himself with regard to the "almost numberless" species on record.

While knowing little of the Monograptidae we detect some signs which tend to make us suspicious of the new genera. Herr Jäkel believes that a classification based (principally at least) upon the characters of the mouth opening could be applied with advantage to all graptolites, including "the two and more rowed." (p. 666.) Again; "All the various types of Monograptids find parallel forms as well among the two-rowed as among the compound forms." Rather unfortunately we think, he continues; "A very remarkable example is furnished by *Monograptus testis*, Barr. which with its aberrant peculiarities possesses its corresponding parallel form in *Didymograptus bimucronatus* Nich., and *Didymograptus quadrimucronatus* Hall" (p. 665). Further reading (p. 676) shows this "parallel" to consist in the possession by *M. testis* of *two spines on the under lip.* This peculiarity the author regards as worthy of generic distinction. Provisionally it is left under *Pristiograptus* but he remarks that if the remaining graptolites should be classified along the lines he lays down this should form the type of a new genus. We confess to having little sympathy with such genera.

[1]Törnquist, Sv. L., 1890, Undersökningar öfv. Siljansomradets Grapt., p. 7.

"The very first lines relating to that genus [Retiolites]. 'Although the general structure of *Retiolites geinitzianus* had already been quite correctly recognized and very aptly figured by Barrande and Süss, it seems to me' etc., seems rather incomprehensible, since it is known that Barrande and Süss entertained entirely different conceptions of the structure of that genus and how sharply the former protested against the latter's interpretation of its rhabdosoma. The author seems to have taken no cognizance of what has been written in recent times on this matter, for example, in as important a work as Tullberg's 'Skanes Graptoliter.'"

This we can well understand as the literature is quite large. Such acquaintance is however, no less a *sine qua non* for successful specialistic work in the graptolitic field than in other departments of science.

The following new species are described: *Pristiograptus frequens*, *Pomatograptus pseudoprion*, and *P. micropoma*.

Die Graptolithen d. k. mineralog. Museum in Dresden, by Dr. H. B. Geinitz. Mitth. k. min. geol. u præhistor. Museum in Dresden, IX Cassel, 1890.

After many years spent in varied paleontological researches, Dr. Geinitz has once more turned his attention to the Graptolites.

The present work is, he tells us, of the nature of a revision in the light of modern investigations of the material which formed the basis for his valuable Monograph of 1852.[1]

The Nereograpti are omitted in the present work. Those forms with an unsegmented canal as *N. cambrensis*, Murch., Dr. Geinitz still considers nearly related to the living Pennatulines (*Virgularia juncoides*, Blainv. and *Funiculina cylindrica* Blainv.) Those with a segmented canal are regarded as allied to the living *Nereis* and *Phyllodoce*, while a large number of the forms are (as shown by Nathorst and others) to be considered tracks, etc., of worms.

We notice that the author includes *Rastrites* (also Jäkel's new genera *Pristiograptus* and *Pomatograptus*) under *Monograptus*. Concerning the propriety of this arrangement we have no opinion to offer as our experience with the family Monograptidæ is practically *nil* and we only note the author's synonymy as it accords with his original views and differs from the consensus of present writers.

More important, it seems to us, is the refusion of such genera as *Climacograptus* and *Dimorphograptus* with *Diplograptus* which thus again tends to include a series of forms whose only similarity is the possession in common of a double row of hydrothecæ. *Dimorphograptus* seems, (so far as we can judge from the studies of others), to be a true transition from the Diplograptidæ to the Monograptidæ. It is of the greatest importance in showing us the futility of classifications based solely on the possession by some part of the polypary of a single or a double row of cells. Before the discovery of the forms included in this genus the Dichograptidæ were looked upon as the ancestors of the Monograptidæ and were even considered monograptids solely because the hydrothecæ occur only on one side of the common canal. The modern improvements in classification form the corollary to recent researches upon the life history of the graptolites, and are in large part based upon the relation of the sicula to the remainder of the polypary.

Relative to *Climacograpus* we must, while entertaining the highest respect for Dr. Geinitz dissent almost *in toto* from the following passage:

"Little regard is here taken of the scalariforms of various Grapotolites (originating through compression of the horny flexible polyp-stem) which Hall has united into the genus *Climacograptus* since its possession by safely determinable species is little assured."

The genus *Climacograptus* is by no means (as one would infer from the

---

[1] Geinitz, H. B. Die Versteinerungen der Grauwackenform. in Sächsen, etc., Abth. 1, Die Graptolithen; Leipzig, 1852.

above), founded upon, limited to, or in any specific way characterized by or connected with scalariform impressions. These impressions are common to many genera but these genera do not for that reason become synonyms for *Climacograptus* as defined by its author. The character by which *Climacograptus* is principally distinguished is the depression of the hydrothecal mouths below the surface of the polypary.

Passing rapidly over that portion of the memoir which deals with synonymy we are glad to see *Stephanograptus*, (Geinitz, 1866), noticed as having clear priority over both *Cœnograptus* (Hall, 1868), and *Helicograptus* (Nich., 1868), as its just claims have heretofore been ignored. Like the other genera mentioned it was founded upon *s. gracilis*, Hall *Graptolithus*.

We regret that *Dicellograptus* Hopk., has not fared better than *Climacograptus*. The definition given of *Didymograptus* is "From a mostly short stalk (the sicula), extend in two opposite directions, sometimes nearer, sometimes farther from each other, Monograptus-like branches." Under it is justly included (and the author includes) the two genera *Didymograptus* and *Dicellograptus* which are universally, and we believe most justly, regarded as belonging to two exceedingly distinct families. But the definition seems to us entirely too comprehensive.

Amid the wreck of genera we are glad to recognize our old friends *Phyllograptus* and *Retiolites* and to meet again on the excellent plates which accompany this work the assemblage of forms which has become classic through the labors of the two pioneers of graptolithology, Geinitz and Barrande.

Undersökningar öfver Siljansomradets Graptoliter by Sv. Leonh. Törnquist. (*Lunds Univ. Arsskrift tom. 26.*)

Previous writings are first passed in review. From forty species in 1881 the number has been increased by a score.

The order of the strata is as follows:

MEMBER.	STRATUM.
Leptæna limestone?	Leptæna limestone?
Retiolites slate	*True retiolites slate. *Transition stratum.
Rastrites slate	*Various zones of Rastrites slate.
Kling limestone	Kling limestone.
Trinucleus member *	Red Trinucleus slate. Grey limestone. Black Trinucleus slate. Masur limestone.
Chasmops limestone	Bryozoa limestone. Cystid limestone. *Flag limestone.
Orthoceras limestone	*Upper grey Orthoceras limestone. Upper red Orthoceras limestone. Lower grey Orthoceras limestone. Lower red Orthoceras limestone. *Phyllograptus slate and green limestone.
Obolus limestone	Obolus gravel limestone. Obolus conglomerate.

*Have yielded graptolites.

The Rastrites slate is undoubtedly capable of subdivisions but the data are defective. A provisional arrangement of zones is proposed.

The author is disposed to question the received opinion that the graptolites are closely related to the Hydrozoa as difficult to reconcile with the structure of *Retiolites* as set forth by himself and Tullberg. Relative to the structure of that genus (*R. geinitzianus*) the views of the author are in complete accord with those of Mr. Holm given above. The relation of the last named species to *Stomatograptus törnquisti*, Tullberg is shown and the identity of Tullberg's species with *Retiolites grandis* Süss, is established by comparison with specimens from Süss's type locality. *Retiolites obesus* Lapworth he thinks should probably form the type of a new genus when better material is obtained.

Passing rapidly over descriptions of species which possess little interest except for specialists we note the suggestion of Herr Törnquist that the genus *Didymograptus* be made the type of a new family, the Didymograptidæ. It differs from the compound dichograptids in having the sicula divided by a distinct wall from the two branches while in the dichograptids the sicula merges without distinct boundary into the thecaphorous hydrosoma. In *Didymograptus* moreover the branches are given off at different levels reminding one of the alternation of theca-formation in the diprionidian graptolites. Further on (under *Phyllograptus densus*, Törnq.) we find that the theca in *Phyllagraptus* are inserted at the same level in whorls of fours. The structure in this genus is that of four monoprionidion polyparies soldered back to back. No distinct virgulæ were observed. The author thinks some specimens show a sicula with the point thrust up into the proximal thecal cycle, but adds that this requires confirmation.

Besides the above outline which contains the gist of such parts of Herr Tönquist's paper as are calculated to interest the general reader, this excellent essay abounds in descriptions which well sustain the character of the Swedish graptolites writings for accuracy of specific definition and painstaking morphological study.

The new species are: *Clonograptus robustus*, *Tetragraptus curvatus*, *Didymograptus gracilis*, *D. decens*, *Climacograptus intenexus*, *Diplograptus bellulus*. In addition to these many previously described forms are figured and their synonymy considered.

Gotlands Graptoliter, by Gerhard Holm; Bihang till K. Sv. Vet. AK. Handl., 1890, XVI, Afd. IV, No. 7, , 2 pls. Also Reprint, Stockholm, 1890.

This excellent paper contains the results of the author's studies of the graptolitic material from Gotland added to the State Museum, since the publication of Linnarsson's paper of the same name eleven years ago.[1]

Linnarsson knew of but three species of Graptolites occurring in Gotland. Tullberg and Lindstrom subsequently increased the number to five. Mr. Holm has added three more so that the list now stands as follows:

[1]Linnarsson G. Ofv. K. Vet. AK. Förh., 1879, No. 5, pp. 3-12.

Dictyonema cervicorne (sp. n.)
Dictyonema abnorme (sp. n.)
Monograptus priodon Bronn.
Monograptus priodon var. flemingii. Salter.
Monograptus subconicus. Törnq.
Monograptus dubius. Süss.
Monograptus sp.
Retiolites geinitzianus. Barr.
Retiolites nassa (sp. n.)

Following in the track of Dames' and Brögger's researches the author discusses the structure of the genus *Dictyonema*. Particularly apt seems to us his views regarding the heterogeneous nature of the species usually referred here. For example we find in this genus a species (*D. flabelliforme*) which is *undoubtedly siculate*, associated with species most of which are probably, and some of which are certainly not so. As he remarks the (for graptolites) unprecedented vertical range of the genus furnishes additional reasons for suspecting some of the generic references. We may, however, note that the siculate and non-siculate types occur at one and the same horizon. But a generic division cannot, as Mr. Holm says, be satisfactorily established until the species are more thoroughly known especially in the proximal portion.

Under the description of *D. cervicorne* we are introduced to one of the most beautiful elucidations of graptolite structure that we have ever seen. The author imbedded a specimen in Canada balsam face down upon a slide, and then removed the limestone matrix by solution with acid. Part of the wall of the funnel-shaped polypary was thus obtained in full relief with the parts in their normal relations.

The thecæ are seen to form one vertical row and to terminate in a long hay-fork like spine. Situated alternately on the two sides of these spines (and thus forming two vertical rows) are peculiar cup-shaped bodies, ("by-thecæ") which are compared by the author to bird's-nests. They are divided from the thecæ by a wall. It could not be ascertained whether any connection existed between these by-thecæ and the adjacent thecæ, or whether the former communicated with the common canal. He suggests that they may be *gonangia*. It is owing to this arrangement of the thecæ in one vertical row along the inner face, and of the by-thecæ in two vertical rows along the lateral faces of the branch that when looked at from the side the branches appear serrate on account of the thecæ and when looked at from without the thecæ are invisible being hidden by the branch, which latter presents a zig-zagged appearance owing to the alternately projecting by-thecæ on either side. The connecting cross-filaments are shown to be flattened from above downward. They are bow-shaped with the convexity outward andpossess a pitted surface and outwardly projecting branches. They correspond in number to the thecæ beween each pair of which they project.

Not less beautiful than the foregoing demonstration is that of the structure of the polypary in *Retiolites geinitzianus* and *Stomatograptus törnquisti*.*

In the former species we see two virgulæ (the one straight and the other zig-zag) occupying the central line of opposite faces of the

*Although many of these points have been previously noted, this description is worthy of mention as it is almost the first based upon thoroughly satisfactory material.

square-prismoid polypary. From each convex angle of the zig-zag and from a corresponding level of the straight virgula, there extends outward in the reticulated wall of the polypary, a chitinous bar ("parietal ledge"). In the ventral (outer) wall of the polypary the parietal ledges are connected by a horizontal "mouth-ledge." Tracing the parietal ledges back toward the central line of the polypary they are seen to be deflected upward in the vertical and inward in the horizontal plane so that they sink below the surface, *i. e.*, into the interior of the polypary. Near the point of deflection they are connected by a bar which traverses the interior of the polypary ("inner cross ledge"). On the trapezoidal frame formed by the mouth-ledge, inner cross ledge and two parietal ledges is strung a fine chitinous network which is an inward extension of the exterior network serving to divide adjacent thecæ. The external network is stretched over the whole surface of the polpary being attached on the ventral surfaces, to the mouth-ledges and on the lateral surfaces to the parietal ledges as far as the point where those ledges become deflected below the surface. At this point the attachment to the ledges ceases and the network is stretched across the median line to the similar angle of the opposite parietal ledge. From all this it follows that three canals extend the length of the polypary in the median line. The central of these is the common canal which is bounded on either side by the inner cross ledges and front and back by the two virgulas. Between this canal and the network (stretched across from angle to angle as described above) lie two canals, one in front of and one behind the common canal. It is thus easy to see what diverse appearances may be presented by one and the same polypary under different degrees and directions of pressure. Preserved in relief neither virgula is visible; the external network with the parietal ledges extending toward but stopping short of the center being all that can be seen, while if subjected to compression, the zig-zag, or the straight virgula (or with greater pressure, both the zig-zag and the straight virgula) becomes visible. The specimen which has furnished this description fails to show an outer envelope or inner dividing walls, but the author cites several authorities to prove the existence of these structures.

In a general way the structure of *Stomatograptus törnquisti* resembles that of *R. geinitzianus*. The epidermic coating of the network is, however, coarser and the virgulas and ledges finer than in the latter species, and the plane of the thecal mouths is oblique to the long axis of the polypary so that in profile the latter appears serrate. In a well preserved specimen of *S. tornquisti* Mr. Holm detected an epidermic layer external, and an endermic layer internal to the network. The outer and inner are smooth and without gaps, the middle alone being cribriform.

Our author believes (but was not able to demonstrate) that interiorly the inter-thecal partition planes are attached to the inner cross ledges. He further believes (in opposition to Tullberg's opinion), that the thecæ were not delimited interiorly by a porous membrane from the common canal but that the communication between the two was unrestricted.

The remainder of this admirable article is devoted to a criticism of Jākel's essay which has been noticed above.

THE FLOOD-PLAIN AND THE MOUND BUILDERS.

By STEPHEN D. PEET, Ph. D., Mendon, Ill.

One of the most interesting problems which the geologist and the archæologist in their combined capacity may undertake to solve is that presented by the flood-plain. The flood-plain is, to be sure, altogether a natural creation while the mound-builders' works are artificial. Yet the two are so related that they may well be studied together. Both are comparatively modern, the appearance of the flood-plain and the erection of the earth-works having been subsequent to the glacial epoch, but both preceded the historic period. Great changes have indeed occurred in them since the historic times, but they are in opposite directions, as the flood-plain seems to be more plainly visible and is fast becoming a regular formation, the last of the sedimentary layers, while the earth-works are fast disappearing and are only advancing in their decay and desolation.

The enquiry which we desire to make has regard to the time which has probably elapsed since the erection of the earth-works as indicated by the growth of the flood-plain.

The first enquiry will be about the so-called elephant effigy which we referred to in one of our former papers. This effigy is on the flood-plain, one of the very few which have been discovered on this plain. The question which we ask is, was it an elephant which was thus built in effigy on a plain which is now occasionally covered with water s as to be cotemporaneous with the ancestors of the Hunter Indians ? The effigy of the elephant seems to have met the same fate in Wisconsin which the rotunda mound has in Ohio. The flood has come up occasionally and washed his feet and his proboscis until his form is obscured beyond recognition. The clover was to be seen growing on the form when we last saw it, the water of recent freshets having drowned out all the clover vegetation in the swale where he lay, but for the life of us we could not tell whether the effigy was of an elephant, a bear or some other huge animal.... We, however, concluded that the effigy must have been comparatively recent for the flood-plain must have been constantly covered with water not a very long time ago; that is, as we reckon time in the history of extinct animals. Our opinion is that the Cherokees built their burial-mounds on the flood-plain of the Scioto in Ohio about the same time that the Winnebagoes built a bear or buffalo effigy on

the flood-plain near Wyalusing, in Wisconsin, and that neither of them were very ancient. This, however, cannot be said of the village enclosures of Ohio nor of the pyramids of the south, for these mounds seem to be now far beyond the reach of floods, and hence older.

Still we have this significent fact that there are in the Davenport Academy some elephant pipes and a tablet with some figures which resemble elephants. Davenport is near the mouth of the DesMoines, not very far from the great Meredosia slough and a little south of Muscatine lake. Now these are all surrounded and full of the late floods and can perhaps be called the last part, or the lowest part, of the flood-plain. No mounds are found on this low ground. But it is claimed that the mound from which the tablet was taken is on the low ground, which might be considered the river bench, only eight feet above high water. Now shall we take this as evidence? The members of the academy maintain that the elephant pipes are genuine. Shall we put the mounds on the river bench back so far as to allow the elephant or the mastodon to have been present, or shall we bring the mastodon up to the time when the river bench was eight feet above the water and when the elephant effigy was frequently submerged? Let us see where this will lead us in reference to the other mound builders and their antiquity. The hunter-tribes of which we are now speaking are the very last of the prehistoric mound builders; there were other tribes which preceded them by many years, perhaps by centuries. We grant the point about the mastodon for the sake of the argument. Then it makes the mound builder to precede the appearance of flood-plain and the disappearance of the mastodon.

We now turn to the mounds of the flood-plains as compared with those on the bluffs. Here we quote from the geological report of Minnesota. Mr. Wm. Colvill says, "The Assiniboines, the Omahas, the Iowas and the Siouxs successively dwelt along the river in this county (Goodhue). All the mounds on the edge of the high bluffs are different from those of the terraces and those on the terraces different from those on the river-bench. All the mounds on the river-bench were said by the Sioux to belong to the Assiniboines. The dwellings were constructed by digging pits and placing posts or supports inside and covering the whole with brush and earth. In case of death within the dwelling

was completely filled with earth, thus burying the house and all. All these mounds show the hearth as a burned clay bottom with charcoal and ashes. The terrace-mounds were built when the flood-plain was covered with water and when the lake reached the base of the bluffs. The mounds on the bluffs were generally loose piles of stones having circular openings or hollow cones high enough for a man to stand erect. They may have been lookouts or war towers. The Iowas and the Omahas came here after the expulsion of the Assiniboines. They had villages at Lake Pepin. There are mounds at Lake City which are said to have been built by the Omahas. There are game drives. The Omahas were driven out of the state by Red Wing and by Wabasha. There are large mounds at Belle Creek in the shape of effigies on an isolated knob, one in the shape of a turtle."

The writer has discovered the same succession of mounds in Wisconsin and other places. Here the latest were nearest the water, those earlier were on the terrace above and the earliest of all on the top of the bluffs. These were effigies. The mound builders proper were in the country when the flood-plains were too wet to admit of access. But the Indians came and encamped on these flood-plains, leaving shells and hearths and debris near the water after the water had subsided. A succession of mound builders filling up the gaps and making the terraces the places where they built their mounds.

Here, then, we have the same story as before; some of the mounds were built since the flood-plain was dry, or comparatively so, these being cotemporaneous with the later Indians, and some of them built when the water was over the terraces and near the bluffs, evidently built by the earlier mound builders.

Let us go down the river farther and look at another class of works. We find a flood-plain but it seems old, and the works on it even older than the plain itself. We can imagine how the hunter kept out of the way of the flood and yet built his burial-mounds on the bluffs adjoining the swamps and lakes. But what shall we say about the agriculturist who built his pyramid on the flood-plain itself? Here is the Cahokia mound; it is 100 feet high, has a terrace 300 feet wide, and fifty deep. It is attended by sixty or seventy other mounds similar in shape and size. These mounds are all on the great American bottom; that bottom is a flood-plain; it is a flood-plain which is now rarely overflowed. The

writer had the privilege of visiting this mound in company with Hon. Wm. Collins who spent his youth at Collinsville near this mound. He informed me that, in the year 1840, this American bottom was overflowed and that steamboats floated over it in rescuing cattle and men, and landed their cargoes at the foot of the bluff three miles from the group of mounds. There has been no overflow for fifty years and the land is now as dry as the prairie. It is covered with fine farms and the mounds are covered with farm-houses and barns, and outhouses, many of them being large enough to accommodate all these and give room for the kitchen garden besides on the summit. Now the point which we make is this: if the hunter mound-builder built his burial mounds before the time of the disappearance of the elephant or mastodon, and the agriculturist built his pyramid upon the flood-plain as a place for an agricultural settlement, how long ago was the mound builder living and filling the scene with his activities? These pyramids were perhaps built while the bottoms were subject to overflow. Perhaps it would be called a city of the mound-builders, but it was a city which in some respects resembled the palafittes or lake villages of Switzerland, "a lake dwelling" on dry land a part of the time, and a palafitte in an overflowed district the other part. The bottom lands extend for eighty miles north and south and are in places some eight and ten miles wide, and are covered with a number of mound-builders' villages similar to the one described....The same fact is also perceptible in the pyramids at Seltzertown and in Bolivar county, Miss.

The drainage of the flood-plain has occurred since the pyramids were built. The pyramids are really older than the flood-plain. The height of the platforms and of the levees or long walls is significant here. In looking over the works we learned that the terraces were all at least twenty feet above the level of the ground. The majority were three times that hight—or were so originally, for many of them have been graded down to make foundations for the farm-houses. Now take a vast plain covered with large farms and villages scattered over it and not a flood that has covered it since 1840 and then put water over it twenty feet with the inhabitants crowded on the summits of their pyramids or crowded on the terraces looking down on the wide spread flood, and you have a picture of the two ages, the historic and the prehistoric, and the contrasts between the two. As to the Buffalo having

been prevalent at this time, we leave that to conjecture and to tradition.

Gen. Claiborne in his history of Mississippi says that the tradition was common among the Choctaws that a race of giants formerly existed at the south and that they used herds of mammoths as beasts of burden. These herds devoured everything and broke down the fôrests. The last animal of the kind had his home on the Tombigbee. The Great Spirit struck him several times with the lightning. But he presented his head to the bolt and it glanced off. Annoyed by this, he fled to the Mississippi and with one mighty leap cleared the stream and fled to the west. Here we have a tradition of the buffalo which formerly roamed as far south as Florida.

We now return to the flood plain in southern Ohio. Here the villages were attended with covered ways and canoe landings, etc. and these covered ways, all of them, end at the edge of the terraces but the water has gone, and the land is high and dry.... This occurs so often that it ceases to surprise us. We find it at Piketon, at Hopeton, at High Bank, at Newark, at Marietta and in fact at every place where there is a covered way....The hight of the terrace above the water varies with localities but it is about equal to the hight of the platforms at Cahokia and ranges from thirty to forty feet. The following are some of the figures given by Squier and Davis....At Piketon the graded way ends at a point half a mile from the river, and there are between it and the river two terraces each twenty feet high. The evidences are, however, that the river "once flowed at the foot of the graded way." At Marietta the grade runs from the upper terrace to a lower one 680 feet long and 150 wide; the hight on which the same enclosure is found is from 40 to 60 feet above the bottom land, and the bottom land is from 35 to 40 feet above the water of the river. The graded way ends at a distance of several hundred feet from the water's edge though "it is supposed that when they were built the water flowed at the edge of the terrace." At Hopeton the covered way formed of parallel walls runs from the village enclosure to the river about half a mile, and is one hundred and fifty feet wide. The walls terminate at the edge of a terrace, "at the foot of which it is evident the river once ran, but between which and the present bed of the stream a broad and fertile bottom now intervenes."....At Seal township the square and circle are upon

the terrace, but the circle is partially obliterated by the wash of the river which formerly flowed near, but is now at a "long distance;" the ancient bed is distinctly seen at the foot of the terrace." The cedar bank works are, on a steep precipitous bank, just above the river, at a hight of about eighty feet, but the wall on the river side has been entirely obliterated, showing that much time had elapsed since the works were deserted. At High Bank the works are seventy-five feet above the river but they extend half a mile south. . . The works at this point have been washed and obliterated by the river, though its bed is now a long distance from the works. A series of works on Paint creek show the same changes. One village was then almost obliterated by the river but the river is now over a mile away. At Newark there is a graded way which formerly ran out to the water's edge but it ends on dry ground, while the covered way on the other side of the village which formerly reached the water now terminates on a wide bottom and the water is at a long distance away. The same is true of the walls at Portsmouth. These formerly extended to the river from the works on the upper terrace across both terraces, and were seven miles in length. They were so arranged as to give the idea of ferries connecting the sacrificial place with the sun symbol in one direction and the square enclosure in the other direction—three groups, two ferries and 24 miles of wall. The walls at Portsmouth have been encroached upon by the Scioto, which has changed its channel and turned toward the wall and now flows where the wall once stood. The works near Dayton were formerly on the same level where now a neat modern village stands. The great Miami however has so overflowed its banks since these works were deserted, that the circle which was farthest away, near the edge of the bluffs, has been washed away and parts of it are not to be seen. The modern village lies entirely between this circle and the river, but the modern village is never flooded.

These facts are significant. The rivers might have sudden freshets and so change their channels and make great havoc with the earth works, but where the land has become so dry and high that white men place their farms, build their houses and erect their villages on it, we may judge that much time has passed. We cannot look upon the earth-works as so recent as some would make them.

As to the beginning of the mound-builder period we will give a few facts. In the last number of the *Popular Science Monthly* Mr. J. F. James has given us a diagram of the old ice dam and of the lake Ohio which was caused by the glacier which is supposed to have crossed the channel of the river here. Now there may be a difference of opinion about this lake and the dam, and yet there is a significance to the map. It is a *map of the territory of the village mound builders*, the most interesting class of mound builders which we have. Of course this does not prove much in reference to their age, and yet the limits of their territory and of the so-called lake are the same. Here we place the reign of the mound builders. If the paleolithic people preceded the formation of the lake, or were cotemporary with it, the neolithic copper-using mound builders were subsequent to it. If the Indians of the hunter class were subsequent to the appearance of the bottom lands while the flood plains had become what they are, the village mound builders preceded them by many years. In this way we read dates into our Archæological records. We have the limits marked by geological changes.

The close of the mound building period. Dr. Thomas has investigated a mound in the Scioto valley which was swept by the floods. ....This mound is near a series of earth works which are called the Baum works situated on the lower land in the vicinity of Chilicothe, Ohio. The argument is that as this mound was so near the village enclosure, and as it contained some peculiar chambers which resemble the rotundas of the Cherokees, the village mound builders were Cherokees, a comparatively modern people. This, however, is the very point which we doubt. The evidence is that Ohio was overrun by a succession of races or tribes and that the early race of sun-worshippers who built walled villages and graded ways and dance circles, and sacred enclosures for burials, never placed their mounds on the flood-plain, but always on the upper terraces; but the Cherokees having been a later race would naturally place their works as did all late tribes on or near the flood-plains.

The growth of the flood-plain in this locality seems to have been at the expense of the terrace on which the majority of the village mound builders placed their enclosures, and so the destruction of the terrace may be regarded as a measure of the time which has elapsed since the villages were deserted. We find the

works of the mound builders sometimes associated with the flood-plain, but the association was more ancient than the proximity of the village was to the water which formerly covered the plain. Formerly the waters flowed peacefully at the foot of the terrace on which the villages were built and the covered ways ran eagerly to meet them. Between these covered ways we imagine the people to have frequently passed, all of the time relying on the earth-wall to protect them from every lurking foe. We imagine also that the canoe navigators frequently landed on the grades or inclines and drew up their canoes, quite secure in their feeling that the friendly stream would not make an onslaught and carry them away. But by and by, for some reason, this very water which was so full and strong began its uncertain, unstable course. It retired from the foot of the terrace, it shrunk away from the villages, it began to flow in the narrow channel, but it was constantly rising and overflowing its old flood-plain, and then the havoc began. The river not only deserted the villages but it turned against them and began to even undermine the defenses, and the walls were soon opened and wide gaps appeared in the enclosures. The villagers, however, had gone before this occurred, for there seems to have been no repairing of the breaches and the water was allowed to do as it would.

In two remarkable cases it so happened, however, that after the villages on the terraces were deserted, and after the flood-plain was sufficiently dry for a later tribe to build its earth-work or its rotunda, then the earth-work appeared which Dr. Thomas calls the Cherokee monument. This is our argument; the village of the sun-worshipper on the terrace, and the rotunda or tomb or whatever it is on the flood-plain, were not really the work of the same people, but that the havoc of the flood against the terrace and the drainage of the same plain all took place since the "lost race" made its appearance and took its departure.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Chemical and Geological Essays. By THOMAS STERRY HUNT. Third edition, with a new preface. pp. XLVI and 489, 8vo, 1891. Scientific Publishing Co., New York. The chapters of this book are as follows:

Theory of igneous rocks and volcanoes (1858); On some points in chemical geology (1859); The chemistry of meta morphic rocks (1863); The chemistry of the primeval earth (1867); The origin of mountains (1861); The probable seat of volcanic action (1869); On some points in dynamical geology (1858); On limestones, dolomites and gypsums (1858–66); The chemistry of natural waters; On petroleum, asphalt, pyroschists and coal; On granites and granitic vein-stones (1871–72); The origin of matalliferous deposits: The geognosy of the Appalachians and the origin of crystalline rocks; The geology of the Alps; History of the names Cambrian and Silurian in geology; Theory of chemical changes and equivalent volumes (1853); The constitution and equivalent volume of mineral species (1853–63); Thoughts on solution and the chemical process (1854); On the objects and method of mineralogy (1867); Theory of types in chemistry (1848–1861). The volume is dedicated to James Hall.

Such topics, covering nearly the whole field of chemical geology, are discussed in Dr. Hunt's well-known style—a style which for breadth of learning and comprehensive scope, no less than for its penetrating, apprehension of the occult relations of chemical and dynamic forces, has caused his writings to be held among our highest speculative authorities on these subjects. The geological literature of the latter half of the nineteenth century will always bear a profound impress derived from the labors of Dr. Hunt.

The Fossil Insects of North America, with notes on some European species. By SAMUEL H. SCUDDER. Vol. I. The Pretertiary Insects, pp. x, 455, with 35 plates. Vol. II. The Tertiary Insects, pp. 734, with map of the Tertiary lake basin at Florissant, Colorado, and 28 plates. (New York: Macmillan & Co. 1890.) A series of eighteen essays, originally published in the Memoirs of the Boston Society of Natural History from 1866 to 1890, forms the first volume of this work, which is limited to one hundred copies. Bibliographic references and an index are added. The longest paper, which bears date of 1879, comprises 111 pages and treats of Paleozoic cockroaches, both North American and European; and another paper of 46 pages, reviews the Mesozoic cockroaches. Winged insects are known to have existed during the Silurian period, but up to the close of Paleozoic time they were represented only by a generalized form, which had the front wings as well as the hind wings membranous. In the Mesozoic era, according to Mr. Scudder, "a great differentiation took place, and before its middle all of the orders...... were fully developed in all their essential features as they exist to-day."

The Second of these volumes was published last year as number XIII of the final reports of the U. S. Geological Survey of the Territories, which was conducted by the late Dr. F. V. Hayden. About a third of this volume, comprising the Arachnida, most of the Neuroptera, and the Orthoptera, was written during the years 1881 to 1884; but the descriptions of the Coleoptera, Diptera, Hymenoptera, and Hemiptera, the last being the most extensive group, were written during the two years immediately preceding publication. For the lower orders, all the Ter-

tiary species from all localities in North America are described, being as follows: Myriapoda, 1; Arachnida, 34; Neuroptera, 66; Orthoptera, 30; and Hemiptera, 266. The collections of the higher orders from the wonderfully rich insect-bearing beds of Florissant yet remain to be elaborated; and for these orders the present volume contains only the species known from other localities, these being of Coleoptera, 112 (including 37 Pleistocene species); Diptera, 79; Lepidoptera, 1; and Hymenoptera, 23. The total number of species thus described is 612, of which 575 are from Tertiary formations, mostly called Oligocene, in Colorado, Wyoming, Utah, and British Columbia. Of the Pleistocene species, 26 were collected by Mr. George J. Hinds in the interglacial beds of Scarboro Heights on the north shore of Lake Ontario near Toronto, none of them identifiable with existing species; and 11 others, likewise now extinct, were found in bone caves at Port Kennedy, Pennsylvania.

When the study of the Florissant collections shall be completed, they will add according to Mr. Scudder's estimates, about 425 species of Coleoptera, besides many Diptera and Hymenoptera. Seven butterflies from the Florissant beds have been previously described by Mr. Scudder in the Eighth Annual Report of the U. S. Geological Survey; and since then another species of exceptional importance has been found. There are also probably eight species of Florissant moths.

The Florissant lake basin lies at an altitude of about 8,000 feet in a narrow valley of the Front Range of Colorado, near Pike's Peak. Its length is 7 or 8 miles, with a maximum width of 1½ miles. Its sediments attain a thickness of 50 feet or more, and consist of volcanic sand and ash, with which, in the upper half, myriads of plants and insects are entombed. The layer in which the insects are most abundant and best preserved has a thickness of about two feet. Lesquereux concluded from his investigation of the fossil flora that the climate at the time of deposition of these beds was much warmer than now, being nearly as at present on the northern shores of the Gulf of Mexico. The few fishes found in the same lacustrine deposits also indicate, according to Cope, a warm temperate climate; and the insects, as Mr. Scudder believes, fully sustain this opinion. No very definite determination of the age of the strata has been reached, but they are referred provisionally to the lower Miocene or Oligocene. Only slight disturbances have taken place since their deposition, for they are still horizontal in their northern part, while their southern part has been uplifted so as to give a northward dip of about two degrees. The inclination caused the lake to be emptied, and since then subaërial erosion has channeled the basin mostly to a depth of 30 or 40 feet, removing the greater portion of its fossiliferous beds, but leaving plentiful remnants of them along its shores and about its islands.

In this branch of paleontology, Mr. Scudder has been almost the sole worker on this continent, and the present volumes well attest his industry and the wealth of his materials.

Tertiary and Post-Tertiary changes of the Atlantic and Pacific coasts; with a note on the mutual relations of land-elevation and ice-accumulation during the Quarternary period. By JOSEPH LE CONTE. Bulletin of the Geological Society of America, Vol. ii., pp. 323–330, with one figure; March 16, 1891. The submarine continuations of the channels of the St. Lawrence, Hudson, Deleware, Susquehanna, and Mississippi rivers are cited as proof that the Atlantic coast of North America was uplifted during the Pliocene period, attaining, probably in the early part of the Quarternary, an altitude of 2,000 to 3,000 feet above its present hight. Its northern coasts were also uplifted, as shown by fiords. The elevation of British Columbia, according to Dr. G. M. Dawson, was at least 900 feet. That it may have greatly exceeded this amount, is indicated by the submerged channels discovered on the coast of California by Prof. George Davidson of the U. S. Coast Survey. Not less than twenty of these sunken fiords have been found between Cape Mendocino and San Diego, within a distance of about 700 miles, some of them reaching depths of 2,000 to 2,500 feet. Like the Hudson submarine channel and fiord, these have all the distinctive features of subaërial erosion, and they are regarded by Prof. Le Conte as decisive evidence that this part of the continental plateau has been greatly uplifted, similarly with its eastern portion and probably at the same time. The submarine channels of California, however, are not continuations of the present rivers, and none exist opposite to San Francisco and the Golden Gate. Professor Le Conte therefore suggests that the drainage of the great valley of California during Pliocene time probably passed into the sea farther south by a deeply submerged channel which is traced by oundings in the Monterey bay. Orogenic movements, accompanying the Quaternary subsidence of the coast, have turned this outlet through the Golden Gate. Others of these submerged channels seem to have been cañons formed by short streams in their descent from the western slope of the Coast Range when it was raised with the whole region far higher than now.

In a supplementary note, the author concludes that the Pliocene elevation of the continent culminated in the early Quaternary, and was one of the causes of the ice-accumulation; that the load of ice caused subsidence below the present level; that the removal of the ice was the cause of the re-elevation to the present condition; but that all these effects lagged far behind their causes.

Composition of certain Mesozoic igneous rocks of Virginia. By H. D. CAMPBELL and W. G. BROWN. Bulletin, G. S. A., vol. ii., pp. 339–348; March 18, 1891. Two exceptional varieties of the otherwise remarkably uniform eruptive rocks occurring in the Mesozoic belt of our Atlantic border are described, with analyses, under the names hypersthene-diabase and olivine-hypersthene-diabase. The former is known at localities in Virginia, New Jersey, and Pennsylvania; but the latter has been noticed at only one locality, near Rapidan, Culpeper county, Va.

The Cinnabar and Bozeman coal fields of Montana. By WALTER HARVEY WEED. Bulletin, G. S. A., vol. ii., pp. 349–364, with a plate

and two figures; March 18, 1891. Bituminous coal of excellent quality is mined both in the Cinnabar field, which occupies a small area on the Yellowstone river just below the National Park, and in the Bozeman field, which lies some forty miles farther north and is of large extent, its coal-bearing strata having been traced about 100 miles. Mr. Weed's work during the past year for the U. S. Geological Survey shows the identity of the coal measures in these areas, and from paleontologic evidence they are referred to the base of the Laramie series. It is noteworthy that the coal of the Bozeman field often rests directly on a sandstone floor, without any intervening layer of fire-clay. The floor is sometimes very uneven, with the coal filling its depressions; but the roof is generally even and regular, and is usually a firm and compact sandstone, needing only a small amount of timbering. Analyses of these coals indicate a low percentage of ash and water, and the complete absence of sulphur has led to their extensive use in the manufacure of coke. In this region the thickness of the marine Cretaceous formations between the lower coal seams and the Jurassic limestones and shales is about 3,600 feet.

On the recognition of the angles of crystals in thin sections. By ALFRED C. LANE. Bulletin, G. S. A., vol ii., pp. 365–382, with one plate; May 4, 1891. This strictly technical paper, which forms a part of the author's work for the Michigan Geological Survey, presents methods of determining graphically the locations of the random sections of minerals under the microscope.

Johns Hopkins University Scientific Expeditions. The University Circular No. 89, for June, contains the reports of the scientific expeditions into southern Maryland; the party, which was composed principally of the students of the University and the members of the U. S. Geological Survey, was under the leadership of Dr. W. B. Clarke, of the University, and Mr. W. J. McGee. The Eocene and Neocene rocks were the ones principally examined; one section of Neocene between Cove and Drum points being particularly fossiliferous, vielding about thirty species. There are also reports on the agriculture by Milton Whitney and one on the archæology by W. H. Holmes.

Remarks on the reptiles generally called Dinosauria. By G. BAUR, Clark University. (Am. Natl. 25, May, 1891, pp. 434-454.)

Dr. Baur reviews this group from Owen's "British Fossil Reptiles" to the present date and concludes that as at present arranged they form an unnatural group. He states, and his evidence and summing up of the different families fully sustain his view, that "The group generally called Dinosauria is an unnatural one, which is composed of three special groups of archosaurian reptiles, without any close relation between each other. The Dinosauria do not exist. The so-called Dinosauria contain three groups of reptiles, which ought to be called Iguanodontia, Megalosauria, and Cetiosauria." He then proceeds to give the distinctive characters of these three groups and finally their geological distribution. Do we understand that Dr. Baur would eliminate the order Dinosauria? On page 447 "* * * the study of the skull alone

would be sufficient to show that the Dinosauria is an absolutely unnatural group without any right to existence; it shows that the three members, Iguanodon, Diplodocus and Ceratosaurus belong to three distinct groups of Monocondylia, with very little relation to each other." In a foot note on page 450, Dr. Baur says: "* * Ceratops Marsh is the same as Monoclonius Cope, as I know from actual study of the types. That Agathaumas Cope is the same as Triceratops Marsh will be admitted by everybody who will compare the original plates of the sacrum, dorsal vertebræ and the ilium of Agathaumas by Cope with those of Triceratops given by Marsh. I think that Macellognathus Marsh which has nothing whatever to do with the Testudinata, belongs to this family (Cœluridæ) and to Cœlurus."

A remarkably important addition to this subject and a discussion of inestimable value.

Two New Reptiles. H. G. SEELEY. (Quart. Jour. Geol. Soc. XLVII, pt. 2, 1891, pp. 164-170.)

Agrosaurus macgillivrayi.—This is described as a saurischian reptile from the N. E. coast of Australia. The specimen has been in the British Museum since 1879, and as it was collected in 1844, has remained undescribed forty-six years. The reptile is named from a complete left tibia, portions of the right tibia, fibula and claw phalanges. The animal was about the size of a sheep and is supposed to have come from the Lower Oolite or the Trias. The shaft of the tibia is slender, proximal end enlarged and curved backward, a slight development of the cnemial crest; distal end uniformly increases in size and a moderate excavation of the distal articulation on the inner side.

Saurodesmus robertsoni.—A crocodilian reptile from the Rhætic of Linksfield north of Elgin. This is represented by one bone, apparently a humerus, which the author terms a "very unsatisfactory specimen." The bone was originally about 10cm. long. The description of this one bone is not conclusive and leaves some doubt as to the true position of the reptile, as according to Lydekker's description of the same specimen, it has Chelonian features.

The Geology of the Barbados. By A. J. JUKES-BROWNE, ESQ., F. G. S. and PROF. J. B. HARRISONS, M. A., F. G. S. (Quart. Jour. Geol. Soc. XLVII, pt. 2, May 1891, pp. 197-243). This is an important contribution, especially to the structure of the coral reefs, which naturally forms the chief component of the paper; there are two appendices by W. H. Hill, Esq., F. G. S. on the Microscopical Structure of samples from Barbados and Jamaica.

A Revision of the Cretaceous Echinoidea of N. A. DR. W. B. CLARK contributes to Johns Hopkins University Circular for April a brief preliminary notice of the Echinoidea of the Cretaceous, in which twenty-one new species are described, principally from Texas and New Jersey.

Important New Mineral Locality.—Dr. G. H. Williams announces and describes anglesite, cerussite, galenite and native sulphur from the Mountain View mine near Union Bridge, Carroll Co., Md. (Johns Hopkins Univ. Cir. April, 1891, p. 73).

The Journal of Morphology announces the forthcoming volume v to contain among other articles, two by Prof. Scott of Princeton "On the Osteology of Poebrotherium" and "A Contribution to the Phyllogeny of the Tylopoda."

An Introduction to the Study of Mammals, Living and Extinct. By WILLIAM H. FLOWER, C. B., F. R. S., etc., and RICHARD LYDEKKER, B. A., F. G. S., London, Adam and Charles Black, 1891, pp. xvi+763.

Aids in Practical Geology. By GRENVILLE A. J. COLE, F. G. S. pp. xiv+402, London: Griffin & Co.; Philadelphia, J. B. Lippencott Co. 1891.

Beiträge zur Geologie und Paläontologie der Republik Mexico. Von DR. J. FELIX und DR. H. LENK. I Theil, se. 114. Leipzig: Arthur Felix.

Fossil Insects of North America. By SAMUEL H. SCUDDER. Vol. I, Pretertiary pp. x+435, 34 plates and Vol. II Tertiary, pp. 743, 28 plates. New York: Macmillian & Co. 1891.

A Catalogue of British Fossil Vertebrata. By A. S. WOODWARD, F. G. S., and C. D. SHERBORN, F. G. S. pp. 396. London: Dulau & Co. 1891.

Tables for the determination of minerals by their physical properties, ascertainable with the aid of a few field instruments, based on the system of PROF. DR. WEISBACH. By PERSIFOR FRAZER; Third edition, entirely rewritten. 12 mo. 115 pages. 1891. J. B. Lippincott Company, Philadelphia.

Irrespective of the contents of this little volume, its external appearance invites to its careful examination. It is bound in flexible-leather cover, presenting the impression of a handy and durable *vademecum* for the actual student of minerals. More restricted in its scope than the "Determinative mineralogy and Blowpipe" of Brush, the "Rock-forming minerals" of Rutley, and the "Practical Guide to the determination of minerals by the blowpipe," of Fuchs, it has a definite purpose which is not deviated, from and which brings it into the curriculum of almost daily necessities of the young field-geologist. By their metallic lustre, or their want of it, all minerals are here classified, there being an intermediate class having a "sub-metallic and non-metallic lustre." Those with metallic lustre are separated by their color at once into red, yellow, white, gray and black. The intermediate class is again divided according to their streak, whether it be black, brown, red, yellow, green or blue. Those with non-metallic lustre and a light streak are separated into five parts, viz: very sectile, sectile, semi-hard, hard and very hard. In this last group evidently fall the great mass of rock-forming and associated minerals, and here the value and aptness of the short descriptions of the double pages, arranged in columns, at once become apparent. With a small kit of simple apparatus, and by the aid of these distinctions, there may be made at least preliminary determinations of nearly all the minerals which the geologist may encounter.

LIST OF RECENT PUBLICATIONS.

I. *State and Government Reports.*

Tenth Annual Report of the State Mineralogist of California for the year ending December, 1890.

Fourth Annual Report of the Canadian Institute, session of 1890-91.

On vertebrata from the Tertiary and Cretaceous rocks of the North-west Territory, by E. D. Cope. Geol. Surv. Can.

Reports of the Director and Treasurer of the Michigan Mining School, 1886-91.

Letter from the Sec. of Agric. transmitting a report on the preliminary investigations to determine the proper location of artesian wells within the area of the 97th Mer. and east of the foot-hills of the Rocky Mts., by J. M. Rusk.

Progress Report on Irrigation in the United States, Part I, by Richard J. Hinton, Washington.

Progress Report of Artesian and Underflow Investigation between the 97° W. Long. and the foot-hills of the Rocky Mts., Part II, by Edwin S. Nettleton, Washington.

Biennial Report of the State Geologist. Geol. Sur. Mo., Arthur Winslow.

Tertiary Insects of North America, by Samuel H. Scudder. Roy. 8vo. pp. 734, U. S. Geol. Surv., Washington.

II. *Proceedings of Scientific Societies.*

Prceed. Amer. Acad. Arts and Sci. New series Nol. XVII. From May 1889 to May 1890.

Report and Proceed. Belfast Nat. His. and Phil. Soc., for the session 1889-90, contains notes on the musical sand of Eigg, by J. Brown, Esq; Some notes on the Upper Boulder Clay, near Belfast, by Robt. Young, Esq., C. E.

Jour. Elisha Mitchell Sci. Soc. 1890, contains: Mineralogical, Geological and Agricultural Surveys of South Carolina, J. A. Holmes.

Proceed. Kan, Acad. Sci. Vol. XII, 1889-90, contains: Artesian Wells in Kansas and the cause of their flow, Robt. Hay; Occurrence of mammoth remains in Franklin county, Kansas, O. C. Charlton; Occurrence of gold in Montana, J. R. Mede; Kansas meteorites, F. H. Snow.

Proceed. Acad. Nat. Sci. Phil. 1881, Jan.,-Mar., contains; Rate of coral growth, Angelo Heilprin; Basanite from Crawford Co., Ind., E. Goldsmith; Palæosyops and allied genera, Chas. Earle; The sandstones of Chester Valley, Penn., Theo. D. Rande; On the age of the Peace Creek beds, Florida, Wm. H. Dall; A review of the Cretaceous mammalia, Henry F. Osborn; Geological reseaches in Yucatan, Angelo Heilprin.

Transactions of the Canadian Institute, Mar. 1891, contents: Pelotechthen balanoides, Arthur Harvey; Formation of Toronto Island, L. J. Clark.

Bul. Santa Barbara Soc. Nat. His., Vol. I, No. 2, Oct. 1890.

Bul. Amer. Geograph. Soc., Vol. XXIII, No. 1, March 31, 1891, Mammoth Cave, Kentucky, Rev. H. C. Hovey.

The Total Eclipse of the Sun, Jan. 1, 1889. A report of the observations made by the party at Norman, Cal. Pub. by Acad. of Sci. St. Louis.

Transactions of the Edinburgh Geol. Soc. Vol. II, Part II, 1890.

III. *Papers in Scientific Journals.*

The Canadian Record of Science, Montreal. Vol. IV, No. 5, 1891, contains: Clay Concretions of the Connecticut River, Miss J. M. Arms; Note on Specimens of Fossil Wood from the Erian (Devonian) of New York and Kentucky, Sir J. W. Dawson and Prof. Penhallow; The Composition of the Ore used, and of the Pig Iron produced at the Radnor Forges, J. T. Donald; On some causes which may have influenced the spread of Cambrian Fauna, G. F. Matthew; The Australasian Ass. Adv. Sci.; Proceedings of the Society; Proceedings of the Microscopical Society.

The National Geographic Magazine, Vol. III, Mar. 28, 1891: South America, by Gardiner G. Hubbard, being the annual address by the president.

Am. Jour. of Sci., April No. Allotropic silver, M. Carey Lea; Phenomenon of rifting in granite, R. S. Tarr; Red sandrock of Marion county, Iowa, C. R. Keyes; Halotrichite or feather alum, from Pitkin county, Colorado, E. H. S. Bailey; Crystallized Azurite, from Arizona, O. C. Farrington; Xenotime as an accessory element in rocks, O. A. Derby; Magnetite ore districts Jacupiranga and Ipanema São Paula, O. A. Derby; Pink gossularite from Mexico, C. F. de Landero; Restoration of Triceratops, O. C. Marsh; Development of the brachiopoda.

May No. Relation of the Pleistocene to the pre-Pleistocene of the Mississippi basin, south of the glaciation limit, T. C. Chamberlin and R. D. Salisbury; Age of the Saganaga syenite, H. V. Winchell; Contributions to mineralogy, No. 50, F. A. Genth, with crystallographic notes by S. L. Penfield and L. V. Pirsson; Ditto, No. 51, F. A. Genth; Columbite of the Black Hills, W. P. Blake; The raised reefs of Fernando de Noronha, H. N. Ridley; Cause of active compressive stress in rocks, and recent rock fluxures, T. M. Reade; Phosphates from the Black Hills, W. P. Headden; Supplementary Notice on the Polycrase of North and South Carolina, W. E. Hidden and J. B. Mackintosh.

June No. The study of the earth's figure by means of the Pendulum, E. D. Preston; Post-glacial history of the Hudson river valley, F. J. H. Merrill; Alunite and diaspore, from the Rosita Hills, Colorado, Whitman Cross; Diaspore crystals, W. H. Melville; Allotropic silver, M. Carey Lea; Notes on the submarine channel of the Hudson river, and other evidences of Post-glacial subsidence of the middle Atlantic coast region, A. Lindenkohl; Are there glacial records in the Newark system? I. C. Russell; Recent eruption of Kilauea, W. T. Brigham; Turquoise in southwestern New Nexico, C. H. Snow.

IV. *Excerpts and Individual Publications.*

Composition of the till or boulder-clay, by W. O. Crosby. Pro. Bos. Soc. Nat. Hist. Vol. XXV, 1890.

The Madison boulder, by W. O. Crosby. Appalachia, Vol. VI, No. 1.

The Kaolin in Blandford, Mass., by W. O. Crosby. Tech. Quart., Vol. III, Aug. 1890.

A new plesiosaur from the Niobrara Cretaceous of Kansas, by S. W. Williston.

A revision of the Cretaceous Echinoidea of North America, by William B. Clarke. Johns Hopkins Univ. Cir., No. 86.

Anglesite, cerussite and suphur from the Mountain View lead mine, near Union bridge, Carroll county, Md., by Geo. H. Williams. Johns Hopkins Univ. Cir. No. 87.

Time-reckoning for the twentieth century, by Sanford Fleming, C. M. G., L. L. D., C. E., etc. Smithsonian Rep. 1886.

Elementary geology, by Chas. Bird, F. G. S., pp. 248, 12mo. Longmans, Green & Co., London.

Descriptions of some new species of fossils from the Devonian rocks of Manitoba, by J. F. Whiteaves. Trans. Roy. Soc. Can. Vol. VIII, Sec. IV, 1890.

Illustrations of the fauna of the St. John group, No. V., by G. F. Matthew. Trans. Roy. Soc. Can. Sec. IV, 1890.

The history of volcanic action in the area of the British Isles, being the anniversary address to the geological society of London on Feb. 20, 1891, by Archibald Geikie, F. R. S., President; Quar. Jour. Geol. Soc. London. Vol. XLVII.

Foraminifera and Radiolaria from the Cretaceous of Manitoba, by Joseph B. Tyrrell, M. A., B. Sc. Trans. Roy. Soc. Can. Vol. VIII, Sec. IV, 1890.

V. *Foreign Publications.*

Annales de la Socéité Géologique du Belgique. 1890. Tomes XVI and XVII.

Records of the Geol. Sur. New South Wales, Vol. II, Parts I and II, 1890. Dept. of Mines, Sydney.

The Mesozoic and Tertiary insects of New South Wales, by R. Etheridge, Jr., and A. Sidney Oliff. Memoirs of the Geol. Sur. New South Wales, C. S. Wilkinson, F. G. S., geological surveyor-in-charge. Dept. of Mines, Sydney.

Verhand. d. naturhist. Ver. (Bertkan), Bonn, 1890, zweite Hälfte, contains: Ueber den Rhein in römischer und vorgeschichtlicher Zeit, Schaaffhausen; Ueber die Braun Kohlenablagerungen im niederrheinischen Tertiärbecken, Hensler; Ueber die Goldfelder Südafrikas, A. Scheuk; Ueber alte Eisthötigkeit und Gebirgsbildung in Skandinavien, Pohlig; Ueber A Schenk, Glacialerscheinungen in Südafrika; und Ueber die carbone Eiszeit. Rauff; Ueber die Quecksilberlagstatte von Almaden, grösster Silberkrystall, Rohlig.

Verhand. d. nat. forsch. Gesellschaft in Basel; Band IX, Heft I, 1890, contains: Beitrag zur Keuntniss der Tertiarbildungen der Umgebung von Basel, A. Gutzwiller.

Verhand. d. Gesell. für Erd. zu Berlin, Band XVIII, Nos. 2 and 3, 1891, Georg Kollm.

Dreissig. Bericht d. nat. wissen. Ver. für Schwaben und Neuburg, früher nat. hist. Ver. in Augsburg, 1890.

Verhand. zool.—bot. Gesell. in Wien, Dr. Carl Fritsch, 1890, XL Band, III and IV Quart.

Sitzungs. d. k. böhm. Gesell. der Wiss. Math.—natur. Classe. II Halbjahr, 1890. Prag. contains: Ueber thierische Abdrücke in der Etage C. c. der Silurformation, J. Kusta; Ueber die Vegetation von Baja-Californien, Dr. J. Palacky; Ueber die Krystall form des Tellurdioxyd und des basischen Tellursulphates, Dr. K. Vrba; Ueber Reste menschlicher Thatigkeit im Diluvium.

Jahresber. d. Ver. für Erd. zu Metz für 1889–90, contains: Eine Besteigung des Etna, Dr. Weigand.

Annalen d. K. K. Naturhist. Hofmuseums, Dr. F. R. Von Haner, Bands V, No. 4. and VI, No. 1. 1890 and 1891.

Jahresber. d. K. böhm. Gesell. d. Wiss. für 1890, Prag.

Geol. Mittheil. zu Budapest, Dr. Moriz Staub, Nov. and Dec. 1890, contains: Ueber das geologische Profil des Schemnitzer Kaiser Francisci Erbstollens, by Ludwig Cseh; Zur Geologie des Djebel-Bu-Kornien Tunis, by Johann Janko; Daten zur Geologie des Bakony, by Franz Schfarzik: Beitrage zur fossilen Flora der Umgebung von Munkacs, by Moriz Staub; Beitrage zur geologischen Beschaffenheit der Umgebung von Munkacs, by Julius Szadeczky.

Geol. Mittheil, zu Budapest, Dr. M. Staub und Dr. J. Szadeczky, Jan. and Mar. 1891.

Bul. de la Soc. Imp. des Naturalists de Moscou, Prof. Dr. M. Menzbier, 1890, No. 2, contains; Le Neocomien des Montagnes de Worobiewo, A. Pavlow; Ueber den Meteoriten von Turgaisk, E. Kislakowsky.

Annual of the Norwegian Geol. Sur. Kristiana, 1890, contains; Graptolite-bearing schists in Vestre Gausdal, by K. O. Bjorlykky Felspar, quartz and mica, their occurrence and industral value, by J. P. Friis; The granite quarries at the Idefjord, by Hans Reusch; Glacial striæ and boulder-clay in Norwegian Lapponie from a period much older than the last ice-age, by Hans Reusch.

Geol. Notes from the Diocese of Trondhjem, by Hans Reusch, Geol. Sur. Norway, 1890, Kristiana.

Salten og Ranen, by J. H. L. Vogt, Geol. Surv. Norway, 1891, Kristiana.

Euvahissement graduel de la mer eocenique aux Diablerets, Origine et age du Gypse et de la cornieule des Alpes vaudoises, Trangressivité inverse, by E. Renevier, Bull. Soc. Vaud. Sc. Nat. vol. XXVII, p. 41.

CORRESPONDENCE.

Dear Sir: I notice in connection with the announcement of the discovery of fish remains in the Lower Silurian rocks of Colorado, by Mr. C. D. Walcott, a statement that the Silurian fish of New Brunswick *Dip-*

laspis acadica is referred to the Lower Helderberg group. Such is not my understanding of the age of the bed in which it was found. It is stated in Trans. Roy. Soc. Can. Vol. VI, Sec. IV. p. 55, that this fish was found in dark carbonaceous shales which are beneath a group of beds containing a Niagara fauna, and that the shales are presumably of the age of the Clinton group. In the preliminary notice of this species it was said on the authority of Billings, that the fauna referred to above was a Lower Helderberg fauna, but Mr. Ami after examining more extensive collections than those sent to Mr. Billings said it was of Niagara age.

My excuse for troubling you with this letter is a desire to have the species credited to its true horizon. G. F. MATTHEW.

St. John, N. B., May 13, '91.

PERSONAL AND SCIENTIFIC NEWS.

THE SCIENTIFIC MEETINGS AT WASHINGTON. The Am. Asso. Adv. Sci. will meet Aug. 19. The Geol. Soc. Am. will meet Aug. 24, and the Int. Cong. Geol. will meet Aug. 26, and continue to Sept. 2. These meetings will all be held in the rooms of the Columbian University, Cor. of 15th and H. streets. A large lecture room, smaller rooms for meetings of the councils, exhibition of maps, rocks, minerals, etc., have been courteously set apart by the Faculty of the University for this purpose.

The Organizing Committee, Int. Cong. Geol. proposes, besides the regular subjects of discussion, such as unfinished business of the former congress, reports of committees, etc., that the following subjects be made special topics for the consideration of the congress at this meeting:

I. Time correlation of the clastic rocks.
   1. Correlation by structural data.
      a. By stratigraphical data.
      b. By lithological data.
      c. By physiographical data.
   2. Correlation by paleontological data.
      { *a.* By fossil plants. / *b.* By fossil animals. } or { *a.* By marine fossils. / *b.* By terrestrial fossils. }
II. General geological color schemes and other graphic conventions.
III. Genetic classification of the Pleistocene rocks.

AWARD OF GEOLOGICAL MEDALS. The Geological Society of London has awarded the various medals at its command to the following persons: The Wollaston Medal to Prof. J. W. Judd, F. R. S., for his work in Petrography and the balance of the fund to Richard Lydekker, Esq., B. A., F. G. S., for his numerous and valuable contribution to Vertebrate Palæontology. The Murchison Medal to Prof. W. C. Brögger of Christiania, and the balance of the fund to the Rev. Richard Baron, F. L. S., F. G. S., of

Antananarivo. The Lyell Medal to Prof. T. McKenny Hughes, F. R. S., for his valuable services, especially among the older rocks, and the Lyell Fund to Dr. C. J. Forsyth-Major of Florence, for his researches in the Pliocene mammalia of Val d'Arno. The Bigsby Medal to Dr. Geo. M. Dawson, F. G. S., of Ottawa, for his researches into the geological structure of Canada.

PROFESSOR CRAGIN HAS RESIGNED the professorship of general natural history in Washburn College, and has accepted a call to the chair of geology in Colorado College.

THE WHEELING W. VA., DEEP WELL. This well was bored for gas to a depth of 4,100 feet, by Ohio county. At this depth all hope of finding gas was given up, and the abandonment of the well was ordered. At the solicitation of Prof. White, of Morgantown, the order was recalled and the well dedicated to science. The company started to drill again, and went to the end of their cable, at 4,500 feet, where the work was stopped temporarily, and officers of the U. S. Geol. survey availed themselves of the opportunity to make temperature observations. Dr. Wm. Hallock, the physicist of the survey, has been in charge, and has already secured preliminary results of exceeding interest. More refined observations will be made on the well before starting to drill again. The citizens of Wheeling have guaranteed the money to pay for future drilling, Mr. Anton Reyman, a public spirited citizen, having become surety for the entire amount required to make the well the deepest hole in the world (about 5,800 feet.) The U. S. Geol. Survey is expected to secure the new boiler aud engine required as well as the steel cable, since it is considered unsafe to use manilla beyond the present depth. These will probably be secured through the generosity of some friend of science. The Survey has already contributed $500 toward the deepening of the well from 4,100 to 4,500 feet. The well offers the best chance to secure an average rate for increase in temperature uninfluenced by local factors that has ever been presented, since it is perfectly free from water, and the region is undisturbed, the rocks dipping only 20 to 30 feet per mile. The Wheeling Development Co. is the name of the organization that drilled the well, Hon. N. B. Scott being president, and J. C. Brady sec'y. The leading manufacturers of Wheeling are the principal stockholders. The well begins at the top of the Upper Coal measures and is now down nearly to the Corniferous limestone.

PROF. J. C. BRANNER, STATE GEOLOGIST OF ARKANSAS, HAS ACCEPTED the position tendered him by the Stanford University at Palo Alto, Cal., but has leave of absence for a year in order to finish the work of the geological survey of Arkansas.

MR. ULY S. GRANT, fellow of Johns Hopkins University, has been appointed an assistant on the Minnesota geological survey.

DR. A. C. LAWSON, of the University of California, has been engaged for the season of 1891 on the Minnesota geological survey.

SUMMARY OFFICIAL DECAPITATION. The regents of the University of Nebraska at a late meeting, with other resolutions adopted the following: That the connection of Prof. L. E. Hicks with the University be severed after August 1, 1891.—*State Journal, Lincoln, Neb.*

MR. RALPH S. TARR, *Cambridge*, has been appointed professor of geology and mineralogy in the University of South Dakota, at Vermilion.

MR. HERBERT A. WILCOX, Tower, Minn., has been employed on the Missouri geological survey, in the examination of the iron deposits or that state.

MR. HERBERT R. WOOD, LATE OF TORONTO, will begin service August 1st on the Minnesota geological survey.

DR. J. FRANCIS WILLIAMS, who has been connected with the Geological Survey of Arkansas for the past two years, has been appointed Assistant Professor of Geology at Cornell University. His report on the igneous rocks of Arkansas is now in press.

PROF. E. H. BARBOUR, GRINNELL, IOWA, has completed aran gements for a paleontological trip in the bad lands the present summer.

DR. GEORGE BAUR, OF CLARK UNIVERSITY, in company with Prof. C. F. Adams, of Champaign, Ill., will this summer, visit the Galapagos islands for the purpose of studying the fauna and particularly the mammoth tortoises, with which the islands abound.

DR. GEORGE H. WILLIAMS OF JOHNS HOPKINS UNIVERSITY is conducting a party of graduate students in geology through western Maryland.

MR. JOHN EYERMAN HAS SEVERED HIS CONNECTION with the scientific department of Lafayette College.

PRINCETON SCIENTIFIC EXPEDITION. The ninth Geological Expedition to the west will, as usual, be under the leadership of Prof. W. B. Scott and will be composed of Prof. W. F. Magie and Messrs. E. A. S. Lewis, A. B. Gladwin, A. W. Bentley, I. Benet, J. S. Hosford, C. C. Jefferson, R. A. Stevenson, R. Coulter, jr. Mr. John Eyerman, of Easton, will join the party during the latter part of the trip.

NOTICE.

The "geological swindler" again abroad. Readers of the GEOLOGIST will recall several references in the early numbers, Vol. I (1888), to an adept thief who had for several years practiced upon the geologists and other scientists of America with a good degree of success. This fellow was apprehended and served six months' imprisonment in the Elkhorn jail, in Wisconsin, but on release resumed his nefarious tricks. In January, 1888, he stole some microscopic objectives from the University of Cincinnati, and under the instigation of Prof. Chas. H. Gilbert, the police of the city were put upon his trail. After a pursuit of some weeks, tracing him in Indiana, Kentucky, and Tennessee, he was apprehended at Nashville, and on trial was convicted and sentenced for five years for grand larceny, to the State penitentiary at Columbus, O. He pleaded guilty and admitted that he was the "swindling geologist" of numerous aliases.

In confinement he made a good record for himself and was put in charge of the night-school. He would have been released, on account of good behavior, at the expiration of three years and nine months under the rules of the Ohio penitentiary, in the fall of 1891, but under special protestations of reform he was given a degree of freedom at Columbus, which allowed of his release finally "on parole" for the remainder of the term that he had to serve. He remained for a time

quietly at Columbus, as reporter for the Columbus *Sunday World*. Suddenly he appeared at Saginaw, Michigan, in violation of his parole, where he attached himself to the High school principal and addressed the pupils of the High school, claiming to have been a professor in Vassar College, Poughkeepsie, N. Y., and then connected with Smith College, but preferring his present occupation of dealing in fossils, as more remunerative. He sold the High school ten dollars worth of fossils. He said he was a Russian, descended from an eminent Russian geologist, and acquainted with the most distinguished geologists of our country—(his usual story, the latter part, alas, too true!), also that he is the brother of the celebrated nihilist martyr Vera Sussulich, that he had fought in the Franco-Prussian war, and had been made a captain, etc., etc. Thence he went to Lansing, Mich., and the speeches he made there were reported in the *Detroit Tribune* under the title—"A man with a history." At Lansing, he claimed to be a mining engineer, and betook himself to the Agricultural College, where he "named the fossils" in the collection of that institution.

On making inquiry as to the identity of this man with the "O. L. Syrski," who had been a short time before released on parole, it was learned that, "in the language of the streets, Syrski has jumped his parole, beaten his boarding-house, and employer, and skipped," with the incompleted sentence still hanging over his head.

He is now again launched upon the community, to continue to be a scourge to scientists and amateurs. In addition to his standard way of representing himself as a geologist (or other scientist more rarely), as a Russian, often as deaf and dumb, and always making memoranda on little squares of colored writing-paper which he carries in very small vest-pocket blocks, and taking occasion to steal valuable books, instruments, and fossils from his hosts, he now has adopted also the method of corresponding with scientists, especially geologists, soliciting exchanges, which of course he conducts dishonestly.

He is thus described at Saginaw; a man of medium hight, of light complexion, with a light colored moustache, blue or grey eyes of great keenness and rather watery, and a firm jaw, giving decision to his conversation. His language is fluent, and free from any foreign accent or peculiarity. He has lost one or two front lower teeth, and looks to be 35 or 40 years old. The attached half-tone reproduction of his portrait is from a photograph taken by the Cincinnati police at the time of his last trial and incarceration. The negative is held by Vail Brothers, photographers, 254 Main street, Poughkeepsie, N. Y., and their price for a single copy is 25 cents. It is a very accurate portrait of him as he appeared three years ago, as many who have suffered from his thefts can testify, except that he is a little more rough in his personal appearance, in the portrait, than usual.

Short notices of his career are given in *The Naturalist's Leisure Hour* (A. E. Foote's), March, 1884 (written by F. V. Hayden), in *Science*, Jan. 14, 1887, June 17, '87, and in the AMERICAN GEOLOGIST, January, February, and April, 1888, and February, 1889. He has appeared under the following aliases: "Grataeap," "Capt. C. E. Dutton, U. S. A.," "Prof. H. S. Williams," "Ellis," "Ellison," "Reitz M.

Vasiliez," "Vasilc," "Vasilief," "Robt. Verrall" or "Varrall," "O. L. Syrski," O. L. Sussulich," "Leo Lesquereaux, Jr." (son of the late eminent paleobotanist), "W. R. Taggard," "Prof. Cameron," "Prof. Leveille," and "E. O. Strong."

No one has yet been found who was a classmate to the swindler, nor has any knowledge been obtained as to the institution where he gained his excellent higher education. He himself declares that he is a graduate of the University of Kief in Russia, but no inquiry seems to have been made into the truth or falsity of the statement. He has shown a familiarity with the Sclavonic languages by conversing freely with Poles and Hungarians in the quarries at Rondont, N. Y., in their own tongues.

We have no vindictive feelings against the man at all, but we believe that we can do no better service to scientists in America than by putting them on their guard against strangers without good credentials, and arming them against "O. L. Syrski," by giving this information.

According to latest information, a one-inch Zeiss microscopic objective, which was on his person when captured in Tennessee, is still in the hands of the chief of police, Cincinnati, unclaimed.

In August, 1887, he procured from Rev. Arthur H. Flack, president of the Claverack College, Claverack, N. Y., a loan of $15 on a spectroscope which he left on his hands "until he should return the loan." Of course the "loan" was never returned, and the stolen spectroscope still awaits its owner at Claverack College.

AMERICAN GEOLOGIST.

May 15, 1891.

TURNS UP AT COLUMBIA, MO.

Columbia, Mo., June 17, 1891.

AMERICAN GEOLOGIST. A few days ago a man came to this place, came to the University and asked the janitor to show him specimems. Next morning he came to me as a "deaf and dumb" man, said he wanted some work to do. Could name fossils, American or European. I told him there was no fund for the purpose. I showed him mine, He then spent the day looking at the university collection. I told him I would pay him to look over our European fossils and correct their names if necessary. He wrote on a paper his name "*Otto Ludovitz Sassulich,*" said he was a brother of Vera Sassulich of Zurich, Switzerland. He is a Russian by birth, and he seemed strangely familiar with every thing, people, places, fossils, but said his deaf and dumbness prevented his working as an active mining expert. Well, I got him at work, in room with him most of time. A few fossils I was in doubt of and asked him, and he was surprisingly correct, knew just where to find descriptions, etc.

While thus engaged one of our professors came in and mentioned about a geological swindler being in Tennessee a few years ago. I then remembered that there was a notice of such a man in June GEOLOGIST, but had not paid much attention to it. It was at hand and I looked and there was the man's likeness exactly. I let him work all day, paid him, then told him he ought to talk, that he was not dumb. Also told him that I knew who he was, and that I thought that a man gifted as he was ought to be evéry way correct. I wished him well, etc., but had not told him of article and portrait, but Prof. P—— of university, hap-

pening in just then, insisted on showing it to him. Of course he denied being a thief, produced a recommendation from Prof. Ed. Orton, also one from ——— of Vassar. He trembled though and hurried off. Don't know where he went, but he certainly is very gifted and smart, and is well posted in paleontology, and would make the best I have ever known provided he stuck to it and honesty.

He did not steal anything here that I know of, may have taken one or two fossils, nothing else, and probably nothing of much value if anything.

Yours, etc..
G. C. BROADHEAD.

N. B. He gave address Columbus, Ohio, and that his mother there would take care of his letters.

THE

AMERICAN GEOLOGIST

VOL. VIII. AUGUST, 1891. No. 2.

THE RECORDED METEORITES OF IOWA, WITH SPECIAL MENTION OF THE LAST, OR WINNEBAGO CO., METEORITE.

JOSEPH TORREY, Cambridge, Mass., and E. H. BARBOUR, Grinnell, Iowa.

It is noteworthy and indeed a remarkable fact that within forty odd years four meteorites of more than ordinary interest,—viz., the Linn Co., Iowa Co., Emmet Co., and Winnebago Co., meteorites,—have been observed to fall in this state. The first, second and fourth of these belong to the "stone" class of aerolites, and the third to the "iron" group.

I. *The Linn Co. Meteorite.*[1]

The Linn Co. Meteorite fell in Hartford, Linn Co., at 2:45 a. m., Feb. 25, 1847. The following fragments are noted, weighing, in pounds: 0.448, 0.369, 0.007, besides other small fragments. They all have the characteristic dull black pitted surface. The color of the interior is a light gray filled with grains of meteoric iron and intersected by cracks filled with crust. The small amount of olivine is quite remarkable.

Analysis of the stony part gave

Silica	60.16 per cent.
Ferrous oxide	23.50 " "
Magnesia	11.20 " "
Magnetic pyrite	4.66 " "
Soda and potash	.30 " "
	99.82 " "

Analysis of the metal gave

Nickel	86 per cent.
Iron	14 " "

[1]From Huntington's catalogue of all Recorded Meteorites, Proc. Am. Acad. of Arts and Sci., 1887, pp. 37, 110.

II. *The Iowa Co. Meteorite.*[2]

The Iowa Co. meteorite fell near Homestead and West Liberty, in Iowa Co., at 10:15 p. m., Feb. 12, 1875. Eighteen fragments are recorded, weighing as follows, in pounds: 11.96, 6.18, 3.85, 3.73, 3.70, 2.96, 1.94, 1.51, 0.63, 0.6, 0.44, 0.31.

The above, with the exception of two or three, are in the collection of Lawrence Smith. They have the usual dead black crust. Specific gravity, about 3.6. Chemically this meteorite is of considerable interest as it is one of the very few in which the occluded gases have been examined and estimated. By heating some of the metal freed from matrix, gases were evolved the constitution of which varied according to the temperature.

At 100° C, the gaseous mixture evolved consisted of

Carbon dioxide	95.46	per cent.
Carbon monoxide	00.00	" "
Hydrogen	4.54	" "
Nitrogen	0.00	" "
	100.00	" "

When exposed to full red heat there was found

Carbon dioxide	5.56	per cent.
Carbon monoxide	0.00	" "
Hydrogen	87.53	" "
Nitrogen	6.91	" "
	100.00	" "

III. *The Emmet Co. Meteorite.*[3]

The Emmet Co. meteorite (called "The Perry Meteor") fell near Estherville, Emmet Co., at 5 p. m., May 10, 1879. Sixteen large masses are on record, weighing respectively, in pounds: 500 (sent to the British Museum, and subsequently divided between London, Berlin and Vienna.) 175 (University of Minnesota), 2.21, 1.81, 1.31, 1.21, 1.07, 0.95, 0.36, 0.32, 0.23, 0.18, 0.14, 0.14, besides many small pieces.

The aerolites belonging to this fall are of the iron type, and consist generally of a network of iron enclosing olivine. The proportion of the two varies greatly in the different individual masses, some being nearly all iron while others contain but little. Crust bluish. The specific gravity of the stony portion was found to be 3.35, of the metal 5.97.

In chemical composition, the Emmet Co. meteorite, so far as examined, has no strongly distinguishing features.

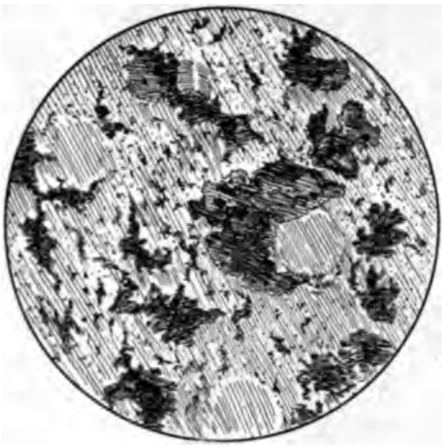
---

[2] Am. Jour. Sci., 2d Series, Vol. VI, p. 405.

[3] Huntington's Catalogue.

IV. *The Winnebago Co. Meteorite.*[4]

The Winnebago Co. meteorite fell near the new town of Thompson eleven miles northwest of Forest City, Winnebago Co., at 5:15 p. m., May 2. 1890. Seven large fragments are noted, weighing respectively in pounds: 86, 66, 10, 10, 60 oz., 60 oz., and, according to professor N. H. Winchell, about 5,000 small fragments, weighing from the fraction of an ounce to a pound or more.



A microscopic section from the sixty-six pound Winnebago stone, showing dark spider-like particles of iron distributed through the matrix.

Between two and three hundred small fragments are in the collection of Yale University alone. About 100 pieces and the 66 pound piece are in the University of Minnesota. Others are owned by Ward and Howell, Rochester, N. Y., and by Geo. F. Kunz, New York. The dead black scoriaceous crust when broken reveals a light grey stone interspersed with innumerable dark particles of iron, and globules of troilite, quite like the Iowa Co. stones in appearance. Thin seams and cracks occur occasionally filled with a substance that has somewhat the appearance of graphite, and small spheroidal masses of olivine are abundant. Specific gravity, 3.638.

Chemical composition of the matrix from a fragment of the 66 pound aerolite:

Silica	47.03	per cent.
Iron oxide	29.43	" "
Oxide of aluminium	2.94	" "
Lime	17.58	" "
Magnesia	2.96	" "
	99.94	" "

This is but the approximate composition, and it is our opinion that nothing else should be offered, and that no analysis yet published is strictly reliable owing to the non-homogeneous character

[4]See Winnebago Co. Meteorites, Notes and analyses of the 104 pound stone. Science June 6, 1890.

Side View.

End View.

Side View.

The Sixty-six Pound Stone.—Its Greatest Diameter is Thirteen Inches.

of the matrix. Another difficulty not sufficiently recognized and taken into account is the extreme difficulty experienced in separating the iron from the matrix by the magnet, a thing practically impossible, owing to the infinitesimal division of the iron, which is still visible under the microscope even in the impalpable powder.

A partial analysis was also made of the metal, separated as completely as was practicable from the matrix, giving the following results:

Iron	95.79	per cent.
Nickel	2.89	" "
Silicon	0.03	" "
Carbon and manganese	undetermined.	
Sulphur	0.68	" "
Phosphorus	0.54	" "
	99.93	" "

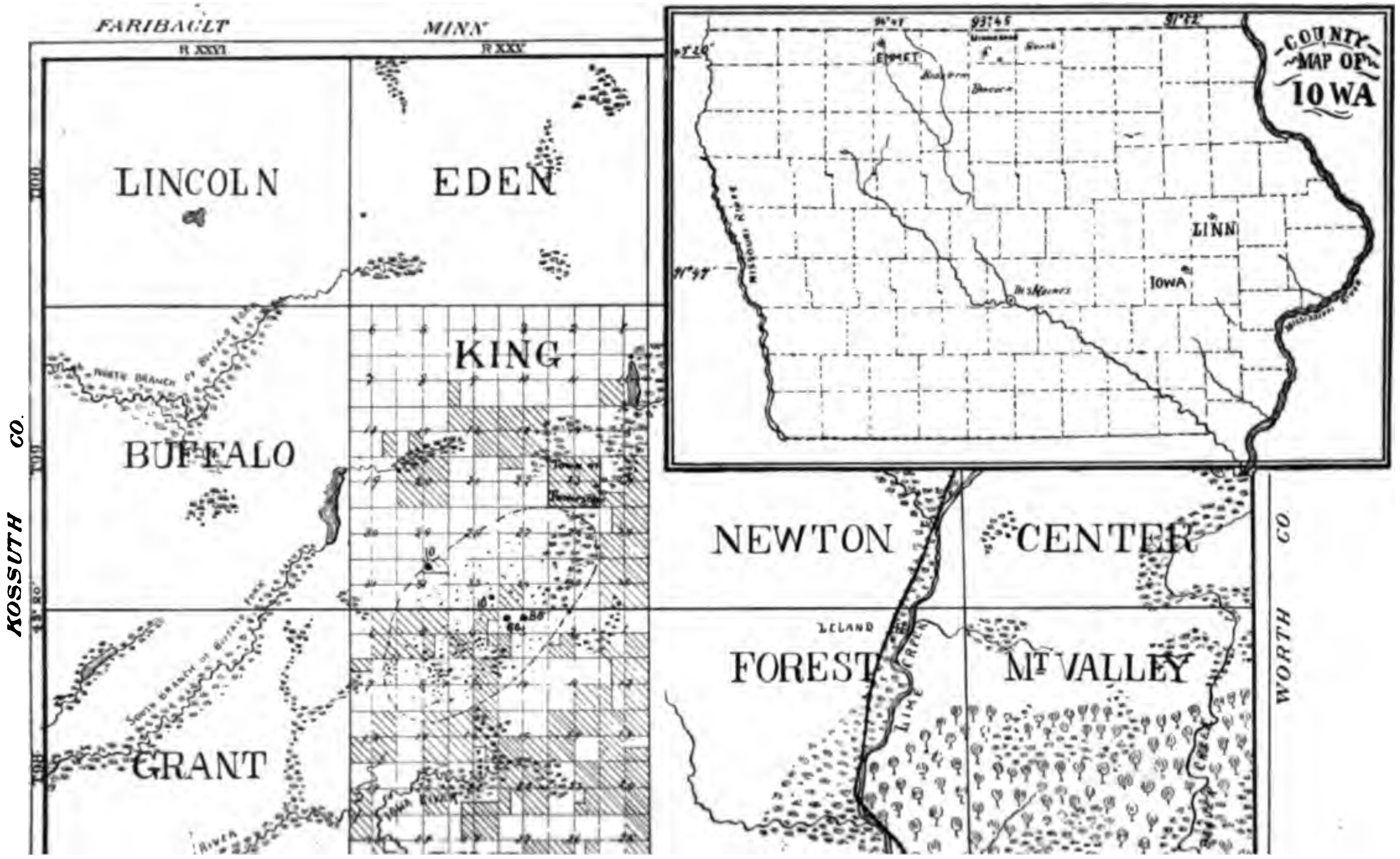
Analyses of this kind appear to be of sufficient interest to publish, but it is most earnestly to be hoped that they may speedily be supplanted by much more thorough and searching ones. Until they are, the sum total of our knowledge of these very interesting bodies will remain as it is now, exceedingly small.

The so-called 104 pound fragment or "Kossuth Co. aerolite," deserves mention here from the fact that it figured in all the earlier notices, at least, as the largest fragment of the Winnebago Co. meteorite, being sold as such to parties in Forest City, whereas it is simply a fraud. Pieces of the boulder, commonly called "nigger-head," were sent us at once for examination. Analysis showed it to be a diorite or allied rock, without crust; no metal present. Gravity (2.83) about a unit lower than that of the meteorite.

In its passage the meteor was seen throughout all Iowa, and observers report it from Kansas, Dakota and Minnesota.

However exaggerated the press reports may have been in certain instances, the fact of its splendor stands nevertheless; so too the fact of the terror which the sudden light, the hissing passage, and terrific explosion inspired in the people of northern Iowa, especially Winnebago Co. and immediate vicinity. Reports from all the towns and cities for many miles around Winnebago Co. liken the noise of the explosion to heavy cannonading, accompanied by a "rushing sound" or unearthly hissing and a noticeable tremor which caused the citizens to fly from their houses to inquire into the cause. This vivid display occurred in the face of a bright spring sun, and an almost cloudless sky. The dazzling head—likened to the moon in size—"sputtering" and throwing off a long

MAP OF WINNEBAGO COUNTY.



train of sparks : the heavy line of black smoke left in its wake to mark its course for a full ten or fifteen minutes : all were seen and marvelled at by the people of several states. Its course to the eye was from southwest to northeast, and its inclination to the earth most commonly judged to be about 55°. One well authenticated but suprising report comes from Tabor, in the extreme southwestern corner of the state, to the effect that the "noise there was like thunder, and was compared by some to an earthquake shock, the jarring of the ground being so evident, and that four distinct explosions were observed by one."

This is a point of considerable interest to us, for at Grinnell but faint noise, if any at all, accompanied the transit. Although the clamor over a hotly contested game of ball on the athletic field of the campus hindered the students and faculty, who saw it, from making careful observations on this point, yet to satisfy ourselves we visited all the farmers for some twenty miles northwest of Grinnell to find but one who thought possibly he heard a noise in connection with the passage through the air. It was surely accompanied by little or only imaginary noise at this point.

The train of smoke left by the meteorite seems worthy of notice. The velocity of the meteorite was such that its transit through the earth's atmosphere was momentary, and at the time the head passed below the horizon, the entire course of the meteor was marked by a broad ribbon of smoke, having straight, sharply defined edges. It was interesting to notice how this ribbon of smoke tapered off toward the higher atmosphere, as if vanishing in perspective, showing the great rarity at that elevation. The smoke began to curl away gradually, but lingered for a full fifteen or twenty minutes before disappearing entirely. The fall was largely on unimproved land near Thompson, covering with fragments an elliptical area some two or three miles long by one and a half wide. (It seems as if the major axis might be taken roughly as the direction of the meteor, that is N.E. as it appeared to the eye. Or, as professor Winchell suggests, the line of direction is more nearly that of the line of impact of the large fragments, that is N.W.) The 66 pound fragment buried itself, close to a farmer in the field, more than three feet in the hard prairie soil. It was not dug out till the next day. Professor Winchell, who visited the spot at once, kindly informs us that the 66 pound stone was not hot when dug out, notwithstanding all reports to the contrary, and that the clay around it was neither baked nor in any way

changed; and that the 86 pound stone fell on old turf, where the last year's grass remained dry, and after the stone was taken out, portions of the grass carried down by it, adhered to the surface unburned. Besides one piece fell on a straw stack, and did not fire the straw.

On the accompanying map of Winnebago Co. the positions of the large fragments are indicated by their respective weights. The counties in which meteorites have fallen are indicated in the small county map of the state of Iowa.

For assistance in preparing the map and for other information, specimens, etc., we are indebted to the Messrs. Secor and Law, and the Messrs. Thompson of Forest City.

ON THE CONTRAST IN COLOR OF THE SOILS OF HIGH AND LOW LATITUDES.

BY W. O. CROSBY.

THE general contrast in color of northern and southern soils has attracted my attention for many years; and six years ago I suggested an explanation of this difference, which is evidently due to the condition of the ferric oxide, in a communication to the Boston Society of Natural History,[1] from which several paragraphs may be advantageously quoted as an introduction to the present paper.

The prevailing difference in color between the soils of the North and South is an unquestionable fact, and must be familiar to many travelers; and yet, but few geological writers have even mentioned it, and, so far as I can learn, no explanation of it has heretofore been proposed. In all latitudes, the most superficial detritus, the true agricultural soil, is, in a large measure, distinctly carbonaceous, or the organic matter has at least been sufficient to more or less completely discharge the brown, yellow, and red colors due to the ferric oxides. But in the surface soil to a considerable extent, and in the subsoil generally, the ferric oxides are still the predominant coloring agents. Now throughout the northern states and Canada the soils, where their colors can be ascribed to ferric oxide, are generally, almost universally, brownish or yellowish, but not distinctly red. The only important exceptions are where the red soil results from the disintegration of a red rock, or is itself geologically old. Thus, the red color of the soil on the Triassic areas, and of the clays at Brandon, Vermont, and Gay Head, does not belong to the present or any recent period, but is due to the peroxidation of iron in Triassic and Tertiary times. On the other hand, one of the most striking features of the scenery of the southern states, especially for north-

[1] Proceedings of the Boston Society of Natural History, Vol. XXIII., pp. 219—222.

ern eyes, is the bright red color of the soil, and the general predominance of this color over the brownish and yellowish tints. This begins to be noticeable in the latitude of southern Pennsylvania, and becomes more and more marked as we cross Virginia into the Carolinas ; while in the West Indies and South America the redness of the soil is even more intense and universal than in the southern states. So far as I have been able to learn by reading and inquiry, this difference in color between the soils of high and low latitudes is more or less distinctly observable in all longitudes, and in the southern as well as in the northern hemisphere.

The brown, yellow and buff colors, so characteristic of northern soils, are undoubtedly due chiefly to the yellow ferric hydrates, like göthite, limonite, and xanthosiderite; while the red color of southern soils, although commonly attributed to hematite, is probably in many, if not most cases due to the red ferric hydrate turgite. The main question, then, Why are northern soils yellow and southern soils red? is really equivalent to, Why is the ferric oxide in northern soils highly hydrated (göthite, limonite, etc.), while that in the southern soils is only slightly hydrated, (turgite), or anhydrous (hematite)?

It is manifestly impossible to answer this question by correlating the difference in color with a difference in the rocks of the two regions; for, while the red clays of the South are found on nearly all geological formations, they appear to have their best development on the primary or crystalline rocks, and these are indistinguishable from the similar rocks of the North. But a satisfactory solution is, I think, found by correlating the color-difference with the one physical feature upon which all the other contrasts between the North and South depend—the climate. In other words, the difference in color depends upon the difference in temperature. It is well known to chemists that ferric hydrate, the coloring agent of northern soils, is dehydrated at the temperature of boiling water; and it seems probable that a partial, if not complete dehydration may result at much lower temperatures, if unlimited or geologically long time is allowed. And, in this connection, it is important to observe that the surface soils of the South attain at times a high temperature, and that in both regions, but especially in the South, the detritus is, quite certainly, chiefly of preglacial origin. The detritus of the South, it is well known, is, except on the flood-plains of the streams, chiefly sedentary, often retaining almost perfectly the structure lines of the rock from which it is derived; while the débris covering the rocks in the North is almost wholly transported, consisting of the modified and unmodified glacial drift. Hence it is evident that the characteristic colors of the North and South are approximately coterminous with the sedentary detritus and drift. But it seems impossible to ascribe the color-difference to glaciation ; for wherever in the North we find sedentary soils, either post or ante-glacial, as in the case of trap dikes which have been decomposed to a considerable depth below the surface of the inclosing rocks, the colors are brown and yellew, never red.

Although it seems not to have attracted general attention, my observations show that frequently, if not always, the red color of the South-

ern soils is a merely superficial phenomenon, being most strongly marked at the surface, and gradually changing to yellow at a moderate depth. This fact, if fully established, will strongly corroborate the view here proposed, that the solar heat is the principal cause of the dehydration of the ferric oxide.

Nearly all soils originate directly or indirectly, in the decay of the silicate minerals of the crystalline rocks, in which the iron is very largely in the ferrous state. And it is well known that the meteoric waters percolating through the rocks not only introduce the carbon dioxide, which is the chief agent in the kaolinization of the anhydrous silicates, but also the free oxygen required for the peroxidation of the iron. The sedentary soils of the South show very plainly also that the second process does not keep pace with the first; for, while the superficial soil exhibits the brilliant colors of the ferric oxides, in the lower portion, which shades off insensibly into the underlying rocks, grayish and bluish tints prevail, indicating that the iron is still chiefly in the ferrous state. Hence the normal vertical order of colors in sedentary detritus seems to be as follows, beginning at the base: 1, Bluish, grayish and neutral tints, due to ferrous oxide; 2, the yellow and brown tints of the ferric hydrates; and, 3, in warm countries, the red resulting from the dehydration of the ferric hydrates.

The foregoing embodies the chief points of my previous paper, which was based very largely upon personal observations made some twenty years ago while I was engaged in mining operations in North Carolina and Virginia, and enjoyed unusually favorable opportunities for observing fresh and normal sections of the sedentary soil. Later, also, I traveled extensively in these and other southern states; in the West Indies, from Cuba to Trinidad and the northern coast of South America; and in Europe, from Sicily to Scandinavia—giving particular attention everywhere to the colors of the soils. That paper was published in the hope that it would call out the observations and views of other geologists; but it appears to have borne no fruit of that kind until the appearance, a little more than a year ago, of the comprehensive and valuable monograph by I. C. Russell on the "subaerial decay of rocks and origin of the red color of certain formations,"[1] to which the author has appended an important bibliographic list. In the first part of this essay relating to the subaerial decay of rocks,

Attention is directed to the widespread decay of the surface rocks throughout the Appalachian region, south of the southern limit of the glaciated area of northeastern America. It is shown, also, that rock-decay is far more advanced in the southern than in the central and northern Atlantic states, and increases gradually southward. This vari-

[1]Bulletin No. 52 of the United States Geological Survey, Washington, 1889.

ation is thought to be due to climatic causes, combined with recent orographic movements which have accelerated denudation in the northern portion of the region under discussion. From the brief review of the geographical distribution of residual deposits in various regions, together with other considerations, the conclusion is drawn that rocks decay most rapidly in warm, humid climates.

After describing the characteristics of the residual or sedentary clays of the South, including the color, Mr. Russell refers to my contribution as follows:

The contrast in color between northern and southern landscapes in the Appalachian belt has recently been explained by W. O. Crosby . . . on the assumption that the observed difference of color has resulted directly from differences of temperature between the North and South. In the essay referred to it is urged that the higher temperature at the South is capable of dehydrating the ferric oxides impregnating the soils, thus changing their color from yellow to red; and also that the red color of residual clays is a superficial phenomenon, confined to the immediate surface of the deposits. My own observations do not confirm these conclusions. At many localities in the Appalachian region south of Pennsylvania where residual deposits were observed, the characteristic red color was seen to extend far below the surface, and as a rule to reach the bottom of fresh exposures. In many localities the color of the residual clays at a depth of twenty or even fifty feet is similar, so far as the eye can distinguish, to the color in the same sections only a foot or two below the surface. The great depth to which the red color extends renders it evident that it cannot be directly dependent on solar heat. Again, over considerable areas in the South the surface clays are various shades of yellow, which would not be expected if the red color of adjacent fields is due to temperature.

During the last six years I have gradually come to attach less weight than at first to the difference in temperature as a sole and sufficient cause of the difference in color between northern and southern soils; but I still hold that it is an important factor in the entirely adequate explanation; and so, apparently, does Mr. Russell. In fact, he proves that the cause must be largely climatic by showing: (1) that the typical residual clays of the South are usually red, and common to a great variety of geological formations; and (2) that, as already quoted, they are conditioned in a very large degree by the combined action of heat and moisture, being but scantily developed in the arid regions of the South, and never with a red color under the humid climate of the North. Since the rocks from which the red clays are derived are almost never red, the redness is evidently incidental to the kaolinization, and its cause may therefore be looked for with much probability, at least, among the conditions favoring kaolinization, of which

heat is clearly one of the most important. Again, in spite of the recent glaciation, evidences of kaolinization are not wanting in the North; but the resulting clay, the true sedentary soil of the North, is never red, indicating very plainly that, while a warm climate is not strictly essential to the formation of residual clays, it is a necessary condition of the development of the red color. Prof. J. D. Dana emphasizes this point in a review[1] of Mr. Russell's work, from which a few sentences may be quoted:

> The contrast in colors between the northern and southern states is spoken of (by Russell) as "contrast between a glaciated country and a region in which atmospheric decay has progressed uninterruptedly for ages." Mr. Russell, knowing less of New England than of other parts of the country, does not appreciate as strongly as professor Crosby, whom he criticises, the full character of this difference. There is wide decomposition at the North, and its rapid progress in the case of syenites, mica schists, gneisses, granites, and hornblende schists during the past forty years, is very strikingly exhibited alongside of many railroad cuts. The fact to be accounted for is that these decompositions over New England, whether in the trap of trap dikes or in metamorphic rocks, produces almost *never* red earth; while at the South, red earth predominates. The glacial movements and orographic changes have nothing to do with this. The fact is simply that in New England the result of the iron oxidation attending the decay is limonite, the hydrous, yellow-brown iron oxide, and not anhydrous Fe^2O^3. The writer has often tried to discover a reason for the different result at the South; he does not find one in Mr. Russell's excellent paper.

In what manner, if any, the milder climate of the South promotes the development of the red color, except directly by favoring the dehydration of the iron oxide, I have not attempted to explain; but when we consider that, aside from the glaciation of the North, there is virtually or primarily but this one physical contrast between the North and South, it seems impossible to doubt the existence, directly or indirectly, of a casual connection between the temperature and the color of the soil. The fact that Mr. Russell questions this conclusion caused me, however, less surprise than his attempt to fortify that negative position by denying that the red color of southern clays is essentially a superficial feature. I was amazed at his statements in this regard, and asked myself again and again if my recollection of what I had seen in the gold mines of North Carolina and elsewhere could possibly be so far astray. Being unwilling to controvert the views of so competent an observer without a fresh examination of the facts, I have waited for an opportunity to go over the ground again. Fortunately,

[1] American Journal of Science, Volume XXXIX., 1890, pp. 317-319.

I have been able during the past year to make two journeys in the South—one to Asheville, by the usual route through the Piedmont district of Virginia and North Carolina, and the other down the great Appalachian valley to the vicinity of the Natural Bridge—giving, in both cases, especial attention to the distribution of the colors in the superficial detritus.

Briefly stated, the general result of these recent observations is a complete confirmation of my original views; but I am able now to make more definite statements than formerly. In the great majority of the sections observed in the Piedmont region of both North Carolina and Virginia, including all which could be described as normal examples, *i. e.*, as unmodified by disturbance or erosion, the distinctly red soil is very superficial, varying in thickness, as a rule, only from two to five feet, and very rarely exceeding ten feet. It is usually reddest, at, or near, the surface, changing downward gradually, more rarely abruptly, through various shades of orange to yellow; while occasional complete sections show the yellow changing through paler tints to gray or the color of the underlying hard rocks. This is certainly the normal succession of colors in a complete vertical section, as described in my earlier paper. The slight depth—two to five or ten feet—reached by the red color was noted again and again in scores of sections. It was usually easy to see, however, how hasty or unguarded observations might lead to a different conclusion; for the wash of the rains has, in most cases, carried the superficial red clay down over the entire face of the section. In this way the orange and yellow are often almost completely blotted out, except where an occasional gully, one to several feet in depth, notches the face of the cutting and exposes a clean, fresh, undisturbed, vertical section of the clays. When passing through the railway cuttings my eyes were always focussed upon these gullies or minature ravines; and when on foot I have proved by actual digging that the yellow color seen in the middle and lower part of the gullies is strictly *in situ*, and that the red color at the same levels between the gullies is what it appears to be, a mere surface wash—a red veil descending from the red crown at the top of the section.

For the past twelve years I have had in my teaching collection a series of specimens illustrating the normal gradation of colors from the surface soil to the underlying rock, which were carefully selected for this purpose at a gold mine in Fluvanna county, Virginia; the entire section, from the surface to the unaltered mica

schist, measuring, in this instance, less than 12 feet, and the red clay less than 3 feet. More recently, I have collected a similar series in the vicinity of Rock creek, in the District of Columbia.

In connection with his criticism of my views, Mr. Russell refers to a quotation, on an earlier page of his essay, from an account by Prof. E. A. Smith of the residual clays of Alabama[1]. Professor Smith's description, so far as it is pertinent to the present discussion, is as follows :

The soil of the red lands is derived from the decomposed hornblendic gneisses and slates, which in many places, where exposed in washes or gullies, are seen to be mere stratified clays, containing fragments, more or less angular, of the quartz veins or seams, which are nearly always interbedded with the other rocks of this region. The top stratum of this soil, from two to three inches in depth, has often a dark chocolate-brown color, but below it becomes a bright red, and at varying depths, from ten to fifteen feet, becomes a *yellowish, hard clay. Where the freshly decomposed rocks are seen the color is yellowish rather than red, the latter color (red) being darker and more intense, apparently, the further removed the soil is from its original position* and the more it is affected by the decay of the vegetable matter.

The italics are my own ; but how this description lends any support to Mr. Russell's criticism is certainly not very clear ; on the contrary, it corroborates my statements that the red color is limited to the vicinity of the surface, and that the deeper and newer clay in every normal section is yellow. Professor Smith's description (which would apply equally well to large areas in Georgia) indicates, what might naturally be expected from the lower latitude, a greater average thickness of the red clay than I have observed in North Carolina and Virginia.

Whatever the cause of the superficial dehydration of the ferric oxide, changing the color from yellow to red, it is unquestionably a slow process ; and since the red portion of the soil is clearly the oldest part, residual, unlike sedimentary, deposits growing from the top downward, we may find here an easy and sufficient explanation of the point in Mr. Russell's criticism to the effect that "over considerable areas in the South the surface clays are various shades of yellow, which would not be expected if the red color of adjacent fields is due to temperature" (page 42). We have only to suppose that erosion, which acts upon all areas in some degree, is here sufficiently rapid to prevent the development of the red color, removing the clay before it has time to change its hue. Mr. Russel has pointed out very clearly that the simple existence of the

[1]Geological Survey of Alabama, Report for 1881, and 1882, p. 184.

residual clays proves a general predominance of decay over denudation; but even where the rate of decay is uniform, the ever varying conditions of erosion must give rise to every phase between the greatest observed depth of undisturbed residual clay with the full complement of colors—red, orange, yellow, and gray—and the hard, bare ledges seen in crags and stream beds; and we may safely predict that in passing from the one extreme of denudation to the other, these tints will, as a rule, appear in succession at the surface.

According to my observations, the surface of the strictly sedentary detritus of the Piedmont region is rarely yellow, except where the conditions are obviously more favorable for rapid erosion than over adjacent red areas. Often in the same limited field it can be seen that the steeper slopes of the land, or, in general, those areas most exposed to the wash of the rains, are yellow, while the more level or less exposed parts are red. The colors thus tend to distinguish the areas of slow and rapid erosion; but it is intended, of course, to embrace in the latter, as in the former, only the general ablation of the surface, and not the gullies so characteristic of southern hillsides, which, when once started, quickly cut clean, vertical sections through the clays. Now the fact that the red clay washed by the rains from the steeper slopes must be spread, in large part, over the more level areas immediately adjoining, affords an obvious and simple explanation, not only of the constantly varying thickness of the red clay, but especially of the exceptionally great thicknesses sometimes observed. I have purposely neglected to take account of these before, because the statement that the red clay is mainly superficial was intended to apply only to detritus that is still *in situ*, or strictly sedentary. No argument is required to show that by rainwash from surrounding slopes the red clay might be accumulated upon a limited area to almost any depth, even fifty feet, as stated by Russell. But it is an obvious mistake to compare such special accumulations of transported detritus, which are in general readily recognized by their situations and horizontal stratification, with clay which is still *in situ*. The same principle also explains the exposure of yellow clay over level areas; for evidently when the red clay has been completely washed from the slopes, the yellow clay will experience a similar ablation; and it is not difficult to see how the conditions would often be favorable to a commingling or inter-stratification of red and yellow clays.

On passing from the Piedmont district of North Carolina to the Blue Ridge and the tableland beyond, the red clay, through the accelerated erosion, rapidly disappears, except in the most protected places. The outcropping ledges and crags are bordered by successive and perfectly blended zones of disintegrating rock, and gray, grayish yellow, and yellow clays; and only, as a rule, on the gentlest declivities are orange and red tints observed. The same conditions were observed in the Appalachian valley, between the Pennsylvania line and the Natural Bridge, yellow and orange being the prevailing colors, and red rarely occurring in considerable patches. Although the comparative absence of the red clay in these more elevated and mountainous areas might be attributed to the colder climate, the correlation with the accelerated erosion appears on the whole more simple and direct; and the latter must certainly be regarded as at least the chief cause.

Although it appears unnecessary to materially modify my previous statements concerning the distribution of the colors in sedentary detritus, I am, as already stated, less disposed than formerly to insist upon the entire adequacy of the warmer climate of the South as an explanation of the red surface soil of that section.

The dehydration of the ferric oxide is not wholly dependent upon heat or pressure or any obvious extraneous agency, but it is in a large degree, apparently, a spontaneous process. Of this we have abundant evidence in nature and in the laboratory. When the iron, which exists in the various silicate minerals chiefly in the ferrous state, is liberated and peroxidized during the decay of these species, it combines naturally with a very large and indefinite proportion of water, forming the yellow hydrate which is seen as a flocculent or a gelatinous colloid in the waters of springs, bogs, and marshes, and when the hydrate is obtained as a precipitate in the laboratory. But this colloid mass, even if immersed in water and entirely undisturbed, gradually and spontaneously gives off a large part of the water which the ferric oxide has so greedily absorbed when in the nascent state; and it appears thus, as it slowly solidifies and hardens, to pass in succession through the forms of the various native yellow hydrates—limnite, *xanthosiderite* and limonite, to göthite. That this progressive change continues is evident from the fact that these yellow hydrates are gradually replaced in the older formations by the red hydrate (turgite) and by ferric anhydride (hematite). When occurring as original or contemporaneous, and not as secondary, deposits, the

yellow ores of iron are found, as a rule, only in the later rocks; while the red ores are generally restricted to the earlier rocks. This genetic relation of the yellow and red ores is one of the most familiar and generally accepted facts in geology. However recent the origin of the red ore (turgite or hematite) may appear to be in any case, we naturally infer that it was first yellow, and that it has passed slowly or rapidly, as the case may be, but gradually, through the series of yellow hydrates.

The frequent absence of any apparent cause for this change leads us to assume that it is essentially spontaneous, in the sense that, although often hastened by heat or other extraneous agency, it would take place eventually without such aid. This view is strengthened by the analogous series of changes exhibited by silica. The gelatinous silicic hydrate obtained in the labratory or seen in the waters of thermal springs, loses water and hardens spontaneously, and eventually reaches the comparatively stable condition of opal, which is comparable with limonite; and since ópal, like limonite, is always of recent origin, we know that it must change more slowly into anhydrous silica or quartz, as limonite changes to hematite. The aluminum and other hydrates manifest a similar tendency. As the dehydration continues, there is a concomitant change from the amorphous to the crystalline state, analogous to that observed in the devitrification of glass and obsidian; and the dehydration is probably as spontaneous as the crystallization.

If it be conceded that the dehydration is virtually, if not absolutely, spontáneous, and there is no apparent alternative, it follows that the color of a deposit, so far as it is due to ferric oxide, is, other things being equal, a function of its geological age. In other words, the color naturally tends with the lapse of time to change from yellow to red; and, although this tendency exists independently of the temperature, it is undoubtedly greatly favored by a warm climate. Applying this principle to the sedentary soil of the South, we find that the superficial portion is red, not alone because it is exposed to a higher temperature than the subjacent yellow clay, but also because it is the oldest part. On the other hand, the limited occurrences of post-glacial sedentary detritus in the North are, in the absence of the favoring climatic influence, still too young to exhibit the change of color even superficially.

It is generally conceded that the glaciated area was, in preglacial times, covered with a continuous sheet of sedentary detritus

similar to that of the South, but probably not so thick. This now forms a large part of the till or bowlder-clay ; and in its colors, thoroughly mixed and greatly diluted with gray (trituated rock), we have the color of the till. A simple experiment shows that a small proportion of the red clay of the South mixed with gray clay gives a decided reddish tinge to the whole. The absence of this reddish tinge in the till may, however, be at least partly explained by the strong erosion attending the preglacial elevation of the land; on the same principal that the red clay is now mainly wanting on the mountains of the South. It seems, however, impossible that a thickness of red clay in the North comparable with what now exists in the South could have been so completely swept away or extinguished as the character of the till would indicate. Hence we naturally fall back again upon the alternative view that the red color was developed very scantily, if at all, in the North, in preglacial times, and that, after all, the climatic difference is an important factor in the true explanation of the contrast in color between the residual clays of the North and South. Certainly no other explanation accounts so satisfactorily for the fact that in low latitudes flows of basaltic lava assume in a few years a bright red color, which never happens in the North. The general conclusion, then, to which the foregoing considerations lead is that the color-contrast is due chiefly to the difference in climate, but that the operation of this principle is modified in a general way by the essentially spontaneous tendency of the color to change from yellow to red.

THE FAUNA OF THE LOWER CAMBRIAN OR OLENELLUS ZONE.

By Jos. F. James, Washington.

This paper* occupies pages 509 to 763 of the tenth annual report of the director of the U. S. geological survey, and it is the third extended paper published by the author upon the Cambrian during the past six years. It is profusely illustrated with three maps, fifty plates of fossils, and numerous sections in the text. The author has been an earnest student of the Cambrian rocks for many years, and students of geology and paleontology will appreciate this presentation of the fruits of his labor.

The paper under consideration treats solely of the lowest divis-

*The fauna of the Lower Cambrian or Olenellus zone. By C. D. Walcott.

ion of the Cambrian : a subdivision of the geological scale that, a few years ago, was regarded as of scarcely any importance even if it were really known , and a subdivision that has scarcely yet found its way into geological text-books. It contains material for the earnest considerations of geologists of America, and if its conclusions be accepted, it must very materially alter many conceptions at present entertained.

In the two previous publications above referred to[1] Mr. Walcott considered the rocks containing *Olenellus* as of Middle Cambrian, and those containing *Paradoxides* as of Lower Cambrian age. A careful study of a complete section in Newfoundland revealed the fact that in reality *Olenellus* occupied rocks *below* those containing *Paradoxides*, and were, consequently older. He was the first to announce the discovery, and promptly corrected the previously erroneous idea. The question of the adoption of the term "Cambrian" in preference to "Taconic" is not entered into, though the former is definitely adopted. A careful study of the literature has convinced him, however, as it would those who give it equal attention, that Cambrian was applied by Sedgwick to rocks below those containing a typical Lower Silurian fauna, as the Taconic was applied by Emmons : and Cambrian has eight years priority over Taconic.

The scope of the paper under review is wide, including a bibliography, an historical review of the literature, and a discussion of the results from both a geological and a zoological standpoint. Under the head of "Historical Review," we find notices of the work of prominent investigators from the time of Amos Eaton in 1818 down to the year 1890. It is true Eaton did not recognize the Cambrian as such in his early work, but inasmuch as the localities studied by him are now known to contain rocks of Lower Cambrian age, it was considered fitting to begin with his work.

The first fossils were found in rocks of this age by Dr. Asa Fitch in 1844. They were described by Emmons in the same year, and referred by him to his Taconic system. Barrande in 1860 identified these fossils as belonging to the Primordial Period, and credited Emmons with the discovery of their stratigraphical position. Mr. Walcott, however, considers that the credit should be given to Barrande, who he says, "was misled by the evidence advanced by Dr. Emmons, which was based on the erroneous inter-

[1]These are Bulletins No. 10 and No. 30 of the U. S. Geol. Survey, published in 1884 and 1886.

pretation of the geological structure by Eaton, in 1824, and followed by Emmons in 1856." (p. 528.)

The discoveries made in various localities by different workers are referred to in some detail, and the geological is followed by an account of the palenotological investigation. In this review mention is made of the different genera and species described between 1844 and 1890. Fossils from the Olenellus zone were not found in Europe until 1868, when Nathorst recorded them from Sweden. Since that date they have been found in Norway, Russia and Great Britian.

In establishing the limits of the Olenellus zone, the base is considered by Mr. Walcott to be "where the genus Olenellus, or the fauna usually accompanying it first appears; beneath that horizon, the strata are referred to some of the pre-Cambrian groups of rocks." (p. 549.) This reference is made irrespective of whether the latter lie conformably beneath or separated by a marked stratigraphic break. In the former case, however, Mr. Walcott considers that possibly the range of the Olenellus fauna, and therefore the Lower Cambrian zone may be extended downward into what are now regarded by him as Algonkian rocks. Descriptions and illustrations of sections in Nevada, Utah, British Columbia, the Grand Cañon of Arizona, eastern New York, Vermont and Newfoundland are given in this connection,

An important and interesting section of the paper is that which deals with the features of the North American continent during Lower Cambrain time. It is considered that the continent was then outlined in a rough way, and had a somewhat similar form to that at present. The fauna lived on both the east and west sides of the continent. "Strictly speaking," he says, "the fauna did not live upon the outer shore facing the ocean, but on the shores of interior seas, straits or lagoons that occupied the intervals between the several ridges that rose from the continental platform east and west of the main continental land surface of the time." The idea here expressed will, if accepted, make it necessary to add a new map to the series illustrating the growth of North America; and it will have to be represented as of much greater extent than the Silurian which came later. The view advanced is considered sustained by the following evidence: (1.) The strata containing the Olenellus fauna are known only in the eastern and western porportions of the continent; (2.) as far as known the Lower Cambrian strata are absent in the interior of the continent; (3.) the

Upper Cambrian strata are unconformably superjacent to the Algonkian and Archean rocks, over areas where the Middle and Lower Cambrian formations are absent; (4.) the strata of the Middle and Lower Cambrian are conformably beneath the Upper Cambrian on the eastern and western sides of the present continent in all sections where the three divisions are present." (p. 557.)

This portion of the paper is illustrated by one map showing the general distribution of Lower Cambrian strata, and by a second upon which are shown a number of sections from typical areas. These indicate the relations between the base of the Lower Cambrian and the rocks beneath, as well as the relation between the top and the overlying series. While a theoretic section across the continent from east to west shows the troughs in which the Lower Cambrian rocks were deposited, and indicates the presence of a land area between the Adirondacks and the Rocky mountains. Other illustrations show the unconformity between the Potodam and the underlying Archean of the Mississippi valley. The general conclusion arrived at is that the interior of the continent, prior to Upper Cambrian time, stood at a relatively high level. This seems to be proven by the accumulation of more than 10,000 feet of sediment in Nevada and in the Wasatch mountains, by the great thickness of strata of Lower and Middle Cambrian age on both the east and west sides of the continent, and the absence of these rocks in the interior. Mr. Walcott further says: "That the Upper Cambrian sea was transcontinental is shown by the presence of the same species of Upper Cambrian fossils in similar stratigraphic relations to strata containing the Ordovician (Lower Silurian) fauna in the valleys of the St. Lawrence and lake Champlain, and on the slopes of the Adirondacks in New York; in the southern Appalachian region of Tennessee and Alabama; in the upper Mississippi valley in Wisconsin and Minnesota; in the sandstones and limestones of Texas and the Black Hills of Dakota, and in the limestones of Nevada and Montana." (pp. 561, 562.) It is not argued that the fauna of these widely separated localities were contemporaneous, but that they have identical stratigraphical relations everywhere to the fauna above, and to that below when it is presnt.

In the notice of European deposits a map is given, copied from one by Hicks, upon which is shown the distribution of the formation and several typical, vertical sections.

A resume of the fauna shows the existence of 67 genera, 165

species and 12 varieties of fossils from this formation in America. In several localities in this country and in Europe no unconformity is found between the Lower and Middle Cambrian, and there is at present no way of accounting for the change from the Olenellus to the overlying Paradoxides fauna.

A number of new forms are described in the last section of this paper, one of them, *Trachyum vetustum* by Dawson and the others by Mr. Walcott. The figures illustrating the species are, in general, excellent. Students interested in the problematic *Cruziana* will find a number of plates illustrating various forms it assumes. The belief is expressed that many of the so-called species were formed by one kind of animal, while even had specific differences existed in the animals themselves, those would not be manifest in the trails or burrows made by them. The trilobites are placed in sixteen genera, and number fifty-three species, forming less than one-third of the entire fauna. Under *Olenellus* nine species are recognized, these being referred to *Olenellus* proper, and the subgenera *Mesonacis* and *Holmia*. The species are illustrated on a series of twelve plates, which are most valuable for comparison. The genus *Atops* of Emmons is discarded and replaced by *Conocoryphe*, upon the ground that it was so badly defined and figured as to be unrecognizable until the discovery of new specimens in the type locality over forty years after its original discovery.

The paper will doubtless create discussion, and while some of the conclusions of the author may not be accepted by all paleontologists, something that can scarcely be expected, certainly all will be glad to have this full presentation.

THE FAUNA WITH GONIATITES INTUMESCENS, BEYRICH, IN WESTERN NEW YORK.

By J. M. Clarke, Albany, N. Y.

Some years ago the writer had the opportunity* of discussing at considerable length the faunas of the Genesee shales and those beds of the "Portage group" which were designated by professor Hall, in 1840, the "Cashaqua shale" and the "Gardeau or Lower Fucoidal group." The data accessible at the time of this work had been collated mainly from the southern area of Ontario and Livingston counties, incidentally from Yates county on the east

*Bull. No. 16, U. S. Geological Survey: The Higher Devonian Fauna of Ontario county, N. Y. 1885.

and Genesee county on the west; they were the result of careful observations made over a period of several years and part of the outcome of the work was a considerable increase in our knowledge of faunas which had hitherto been regarded as exceedingly meager and uninviting to either the geologist or palæontologist.

Since the publication of this paper the writer has taken every opportunity (always with the co-operation of his friend, Mr. D. D. Luther, of Naples,) to add to his representation and knowledge of these faunas. It has been inconvenient to undertake any systematic investigations in the country adjoining either on the east or west, but such desultory tours as have been made over the outcrops of these formations in the neighboring counties, lead to the conviction that certain important faunal characters are more positively developed in the Ontario county section than elsewhere, and that for the study of these fossil faunas in their fullest development no area is as favorable as that which circumstances have made it convenient to thoroughly investigate.

The large amount of new and highly interesting material that has been obtained from these beds now makes the faunal lists of quite formidable size; furthermore, the fossils, though of somewhat rare occurrence, are not of such inferior preservation as one would infer from an inspection of the most extensive palæozoic collections of the country, or from a few days' or weeks' collecting tours in the field; they have, with patient work, proved moderately abundant and often of exquisite preservation; indeed, we now possess series of many of the species, which afford the developmental stages from early age to maturity. It is the hope and purpose of the writer to eventually elaborate these interesting faunas and the growth-phases of their component species; the object, of the present paper, however, is to indicate their quantivalence and time-values.

Along the meridional section indicated, in a general sense that of Canandaigua lake, the Genesee shales lie directly on the upper shales of the Hamilton group, the Tully limestone having thinned out and disappeared a few miles to the east. These shales have here essentially the same lithological characters and variation as on the High Banks of the Genesee river, their separation from the underlying argillaceous Hamilton shales being rather more abrupt than is usual between formations of shaly rocks following each other conformably. Toward their base they are somewhat arenaceous, but rapidly become very bituminous and heavy-bedded, these

latter layers bearing quite sparingly traces of conodonts, fishes and plants, with *Leiorhynchus quadricostatus* and *Orbiculoidea lodensis*. Toward the top they again become argillaceous.

The fauna of the upper and lower shales is very meager at the best, and consists essentially of these species :

Goniatites uniangularis Conrad,	*Coleolus aciculum* Hall,
Pleurotomaria rugulata Hall,	*Lunulicardium fragile* Hall,
Leiorhynchus quadricostatus Vanuxem,	*Orbiculoidea lodensis* Vanuxem.

This is a well known combination characterizing the black shales throughout their extent in this state, eastward and westward of this meridian.

Shortly after the retreat of the Hamilton fauna and the first appearance of bituminous sediments with this association of organic remains, there appeared an interesting incursion of species which invites special attention. This faunule has been studied only at a single outcrop in Bell's gully, on the east shore of Canandaigua lake, in a thin band of black shale but few feet from the base of the series and distinguishable from that immediately above and below only in being slightly less sandy. It would be natural to expect, among the earlier portions of these sediments, some indications of a more or less restricted return of the characteristic association of the Hamilton ; such indications, indeed, it is quite likely will be found, but this little assemblage is not of such a nature. The following species have been identified :

Conodonts in considerable variety.
Entomis sp.
Fragments of an undetermined phyllocarid crustacean.
Orthoceras sp.
Hyolithes sp., unlike species of the Hamilton or succeeding faunas.
Tentaculites sp.
**Styliolina fissurella* Hall ; not especially abundant.
**Pleurotomaria capillaria* Hall.
**P. itys* Hall, var. *tenuispira* Hall.
**P. rugulata* Hall.
Nuculites, sp. nov.; abundant.
Lunulicardium, sp. nov.; a spinose species occuring both in the Styliola layer and the Naples beds.
Cardiola Doris Hall,
C. (*Buchiola*) *retrostriata* von Buch,
Phthonia like *P. nodocostata* Hall, but persistently smaller in size.
**Chonetes lepida* Hall,
Chonetes, cnf. *aurora* Hall,
Twigs of *Psilophyton* or *Rhachiopteris*.

The usual species of the black shales are thus seen to be almost wholly absent from this assemblage. Such of the species (those

marked with an asterisk) as have appeared in the faunas of the Hamilton series, continue their existence to a still later period and they, together with *Lunulicardium* sp. nov., *Cardiola Doris*, and *C. retrostriata*, constitute an association which is emphasized in the more abundantly developed faunas of the Styliola layer and the Naples beds.

Exceedingly interesting is the occurrence of a form of *Chonetes* which it is difficult to separate from *Chonetes aurora* Hall, a form known in New York only in the fauna of the Tully limestone, to which reference will subsequently be made.

Above the most densely bituminous layers of the Genesee shales and near the middle of the series, occurs the stratum which has already been termed the *Styliola layer*;* a bituminous limestone but a few inches in thickness, often compact, sometimes of a subcrystalline and loose texture, at others inclined to be shaly or actually passing into thin chocolate-colored shales, nevertheless persistent over an east and west strike of at least 20 miles. It is essentially an accumulation of millions upon millions of the minute pteropod shell known as *Styliola* or *Styliolina fissurella* Hall.[2] Only in a few places does this fossil appear to have given way to an inorganic argillaceous calcareous matrix.[3] The fauna of this layer is an assemblage of species, some of which occur in the Genesee shales above and below, but many of them appear here for the first time. The following list, though incomplete on account of including several important undescribed species, is still sufficiently full to serve our present purpose:

Dinicthys newberryi Clarke.

Palæoniscus devonicus Clarke, (also in the Naples beds).

Undetermined plates and scales of fishes.

Conodonts, (not common, but similar in form to those below, and in the Naples beds above).

---

*See Bull. U. S. Geological Survey, No. 16 and Neues Jahrbuch für Mineral. 1891. Bnd. 1.

[2]For a figure of a thin section of this pteropodal limestone, see Nicholson and Lydekker's Manual of Palæontology, vol. 1, page 24, fig. 8. 1889. This illustration does not show the interesting effects produced by the crystallization and cleavage of the calcite, which are referred to in Bulletin No. 16.

[3]The position of this layer is just above the heavy bituminous beds and not far from the middle of the series. In the Bell's gully section the lower arenaceous shales are thin and contain stragglers from the Hamilton molluscan and crustacean fauna with a great abundance of *Leiorhynchus quadricostatus*. They are about 15 feet in thickness, the overlying heavy bituminous beds having a thickness of 112 feet. Above the *Styliola layer* there are 85 feet of the more sandy black shales overlaid by the green shales and thin sandstones of the Naples beds.

Goniatites intumescens Beyrich, (=*Goniatites patersoni* Hall; I have collected and studied scores of specimens of this species from the Intumescens-kalk of Westphalia and the Hartz and can find no single detail or general feature on which to base a separation of this from the typical German form. Also in the Naples beds).

Goniatites uniangularis Conrad, (abundant; also in the Naples beds).

Goniatites nodifer Clarke, (in the Naples beds?).

Goniatites sp. nov. (a), (a deeply umbilicated primordial species with *intumescens* sutures and very strong concentric growth-varices on the younger whorls. Also in the Naples beds).

Goniatites sp. nov. (b), (a small primordial species with flattened dorsum; compare *G. forcipifer* Beyrich. (Also in the Naples beds).

Goniatites sp. nov. (c), (allied to *G. intumescens* but closely umbilicated and with more inflated whorls. Not common).

Goniatites sp. (d), (similar to *G. uniangularis* but sharply carinate on the dorsum).

Orthoceras pacator Hall. (To this species is referred the commonly occurring *Orthoceras* of the rocks, a smooth, terete form with constriction on the chamber of habitation. Also in the Naples beds).

Orthoceras aciculoides Clarke, (also in the Naples beds).

Orthoceras? filosum Clarke. (The surface markings of this species are similar to those of the genus *Pharetrella* (*P. tenebrosa* Hall); it may prove to belong here. Also in the Naples beds).

Orthoceras sp. nov. (a).

Orthoceras sp. (b).

Orthoceras sp. (c)

Gomphoceras sp. nov. (a).

Gomphoceras sp. nov.? (b).

Bactrites sp. nov. (also in the Naples beds).

Coleolus aciculum Hall; (also in the Naples beds),

Tentaculites gracilistriatus Hall, (also in the Naples beds).

Styliolina fissurella Hall, (exceedingly abundant in the Naples beds).

Bellerophon striatus (Fer. and d'Orb.) Bronn.

Bellerophon incisus Clarke, (also in the Naples beds).

Bellerophon sp. nov. (a).

Bellerophon sp. (b).

Loxonema noe Clarke, (also in the Naples beds).

Pleurotomaria cnf. *itys* Hall.

Pleurotomaria itys, var. *tenuispira* Hall, (also in the Naples beds).

Platystoma minutissimum Clarke. (This little shell is so exceedingly abundant both in the Styliola layer and in the concretionary layers of the Naples beds that there may be good reasons for regarding it of pteropodal nature, like *Limacina* and *Spirialis*, but dextrally coiled).

Platystoma sp. nov.

Macrocheilus sp. nov., (also in the Naples beds).

A new gastropodous genus, suggestive of *Autodetus* Linnarsson, but a true phorid.

Lunulicardium fragile Hall, (also in the Naples beds).

Lunulicardium ornatum Hall, (also in the Naples beds).

Lunulicardium sp. nov. (a), (with spines on the lunule; also in the Naples beds).

Lunulicardium sp. nov. (b).

Nucula sp.? cnf. *diffidens* Hall, (also in the Naples beds).

Lucina? ? cnf. *suborbicularis* Hall, (also in the Naples beds).

Lucina? ? sp. nov., (also in the Naples beds).

Cardiola (*Buchiola*) *retrostriata* von Buch, (not uncommon; very abundant in the Naples beds).

Cardiola doris Hall, (also in the Naples beds).

Strophalosia, a small species like *S. truncata* Hall).

Chonetes lepida Hall.

Leiorhynchus sp. ?

Lingula spatulata Vanuxem (also in the Naples beds).

Orbiculoidea, (a very small species).

Cladochonus? sp.

Melocrinus clarkii Williams, (also in the Naples beds).

Cladoxylon mirabile Unger.

Dadoxylon clarkii Dawson, (also in the Naples beds).

Dadoxylon newberryi Dawson.

Cyclostigma affine, Dawson.

Lepidodendron primævum Rogers (Dawson's identification. Also in the Naples beds).

Lepidodendron gaspianum Dawson.

This association of organisms was broken up with the closing of the comparatively brief period of time represented by the *Styliola layer*, and only occasionally do representatives of the fauna appear scattered through the overlying mass of dark shales. A few forms, e. g. *Cardiola retrostriata*, *Loxonema noe*, *Pleurotomaria itys*, var. *tenuispira*, return in the upper levels of the series, in association with characteristic Genesee species, *Lunulicardium fragile*, etc.

Thereupon follow the compact greenish sandy shales with thin laminated sandstones, which characterize the Cashaqua shales, or base of the "Portage" series.

The lower beds of these greenish shales and flags alternate with two or more considerable beds of black shale, which are, at times, exceedingly bituminous and very heavy-bedded, but usually somewhat arenaceous, in other words, are very like the Genesee beds beneath. The characteristic fossils of the Genesee beds do not, however, reappear at these horizons as far as known; indeed, the only invertebrate fossil that has been found here is an interesting goniatite allied to *G. chemungensis* Hall, and described by the writer as a variety of that species; a form with a multilobate septal suture like *G. clavilobus* Sandberger, a lower Upper Devon-

ian (Intumescens-kalk) species occurring at Brilon, Westphalia.* Fish remains are sparingly found, (*Palæoniscus devonicus*, *Acanthodes? priscus*, and several undetermined species) with occasional fragments of *Lepidodendron* and other plants. The shales lying between and above these bituminous bands became filled upward with increasing amounts of sandstone until gradually and finally the thin-bedded sandstones predominate over the shales.

It was to this portion of the Portage series that the term "Gardeau or Lower Fucoidal group" was originally applied, and to the upper and overlying beds which are mostly heavier bedded sandstones, the name "Portage or Upper Fucoidal group." The fact is that the alteration in the lithological nature of the sediments has been a very gradual evolution and it is quite impossible to uphold a satisfactory division of the series on such a basis. The palæontological evidence is different. With the introduction of the green shales of the Cashaqua or basal division of the series, we find certain species of the *Styliola fauna* reappearing. These become more abundant or are at least better retained in the beds of shales lying between the first and second bituminous bands or wherever there is sufficient calcareous matter in the strata to form subconcretionary lenticles.

It is here that the fauna attains its highest and most characteristic development, but so far forth as the shales prevail, even after the very material encroachment of the more arenaceous sediments, the same fauna accompanies it. We refer to the fauna in its *toute ensemble*, the variations in the faunules of a given stratum from that of the next above or below being of limited significance either geologically or palæontologically. In the lower beds the species of the shales are occasionally found in inferior preservation, in the thin layers of sandstone, but as the sandstones become heavy-bedded and more continuous, this is a rare occurrence. Reference has been made in Bulletin No. 16, (p 68) to the appearance in the midst of the "Portage" sandstones, that is, in the upper member of the series lying between the Genesee shales and the Chemung sandstones, and about 600 feet below the earliest known occurrence in this section of a fauna with *Spirifer disjunctus* and *Orthis impressa*, of an assemblage of brachiopods, *Leiorhynchus mesacostalis*, *Ambocœlia umbonata*, *Atrypa aspera*, *Rhynchonella eximia*, etc., which are a new association and one

*Kayser. Zeitschr. der deutsch. geolog. Gesellsch. vol. xxiv, p. 667, 1872.

reappearing constantly together with *Spirifer disjunctus* in the normal Chemung fauna. Directly beneath this level is the last known appearance of the fauna of the shales below.

It has become evident that the original terms applied to subdivisions of the Portage series have a very restricted lithological value and must lead to deception in regard to the faunal contents of the strata. It was for such a reason that the writer has made use of the term *Naples beds* for the former and *Naples fauna* for the latter ; the use of the term Cashaqua would express but a part of the truth, and the combination in one appellation of both *Cashaqua* and *Gardeau*, would gain in ugliness what it lacks in precision.

Attention is again briefly directed to a peculiar concretionary limestone stratum occurring in the Naples beds about half-way between the top of the first and the base of the second band of black shale. This is a thin, quite persistent layer, bearing a considerable intermixture of silica and pyrite, in color passing from a gray into various shades of green and red. It is a fine example of the "Knollen" and "Kramenzelkalke" of the Germans, so characteristic of the lower Upper Devonian horizons in Westphalia and also described by F. Roemer, Lee, Champernowne and most recently by Ussher. This stratum is full of goniatites, principally *G. intumescens*, associated with *G. uniangularis*, *Orthoceras pacator*, *Bactrites sp.*, *Loxonema noe*, and with immense numbers of *Platystoma minutissimum*. A similar formation is not known to occur elsewhere in the Devonian of America, and its significance will appear in the comparison of the species of the Naples fauna with their representatives in other countries.

The accompanying list of the species of this fauna is necessarily incomplete. Many interesting forms are undescribed and their affinities can only be indicated.

THE FOSSILS OF THE NAPLES BEDS.
(Intumescens Fauna)

Palæoniscus devonicus Clarke, (bituminous bands)
Acanthodes priscus Clarke. " "
Conodonts in considerable variety " "
Echinocaris whitfieldi Clarke. " "
Echinocaris? beecheri Clarke.
Spathiocaris emersoni Clarke.
Goniatites intumescens Beyrich, (= *G. patersoni* Hall). These shells agree with the typical form of Beyrich's species, that with a rounded dorsum, and are much more closely adherent to this type than many shells which are referred to this species in the German Devonian. The

American species does not become carinate nor evince an appreciable degree of variation in a large number of specimens. It is the predominant goniatite of the fauna.

Goniatites sinuosus Hall. Specimens of *G. intumescens* which have been exposed to weathering since fossiliation or to maceration before it, often exhibit peculiar modifications of the septa. The specimens found in the thin sandy layers or flags are usually thus modified and in some of their conditions are similar both in exterior and septum to those which have been described as *G. sinuosus* and *G. nundaius*. I am at present inclined to believe that *G. sinuosus* is only a condition of *G. intumescens* resulting from modification by mechanical and post-vital influences. The species known in the Intumescens-kalk of the Iberg-Winterberg, Hartz, and Adorf in Waldeck, as *G. carinatus* Beyrich, is, in every respect similar to *G. intumescens* save in the fact that the lower lateral lobe is rounded instead of acute. This, however, is a feature which characterizes an undeveloped condition of *G. intumescens*, as shown by Holzapfel and myself, and it is questionable if the forms can be properly separated on such a basis.

Goniatites uniangluaris Conrad. One of the Simplices, very closely allied to *G. retrorsus simplex*.

Goniatites bicostatus Hall. Another member of the same group.

Goniatites lutheri Clarke. One of the Primordiales with sharp lateral saddle. I know no species with which this may be directly compared.

Goniatites complanatus Hall. This species was originally described as *Clymenia? complanata* in the Report on the Geology of the Fourth District of New York; the figure accompanying the first description gave only the exterior of a flattened specimen having the same expression and degree of umbilication as *G. lutheri*. The subsequent illustrations and description of specimens referred to this species in volume v of the Palæontology of New York, show a septum like that of the Simplices and totally different from that of *G. lutheri*. I have been unable to discover the original specimen of *G. complanatus* either in the New York State Museum or the American Museum in New York city, and without it, it will be impossible to determine the value of the species. The designation *complanatus* may under the circumstances properly be applied to such goniatites as show the suture referred to, and must be limited to such. However, no goniatite of this character is known to me in this fauna.

Goniatites chemungensis Hall, *var.* Clarke. The single specimen is from the lower black shales and shows no suture: should it prove to be allied to *G. chemungensis* it may be regarded as a respresentative of the Irregulares.

Goniatites sp. nov. A very large representative of the Nautilini, closely allied to *G. Roemeri* Holzapfel (Adorf). See Gon. (b), Styliola layer.

Goniatites sp. With a broad, grooved and rounded dorsum; in external characters it may be compared to *G. evexus* von Buch; internal characters not known.

Goniatites sp. (G. sp. nov. (a) Styliola layer). A primordial species

with strong concentric flutings on the early whorls, which become less conspicious with age and at maturity form sharp, close, concentric lines.

Goniatites sp. A species with a broadly flaring chamber of habitation and suture similar to that of *G. müensteri.*

Goniatites sp. A primordial goniatite like *G. intumescens*, but small, less umbilicate, with closely crowded septa and sharply angled lobes and saddles.

Goniatites sp. A deeply umbilicated species, with broad grooved, dorsum and costate whorls ; cf. *G. tuberculatus* Holzapfel.

Besides these species of goniatites there is some more or less imperfect material which indicates the existence of a few additional forms.

Orthoceras pacator Hall.
Orthoceras aciculoides Clarke.
Orthoceras ontario Clarke.
Orthoceras filosum Clarke.
Orthoceras sp. nov.
Bactrites sp. nov.
Bactrites sp.
Hyolithes neapolis Clarke.
Coleolus aciculum Hall.
Tentaculites gracilistriatus Hall.
Styliolina fissurella Hall.
Macrocheilus sp. nov.
Platystoma minutissimum Clarke.
Pleurotomaria itys, var. *tenuispira* Hall.
Palæotrochus præcursor Clarke.
Loxonema noe Clarke.
Bellerophon nataor Hall.
Bellerophon incisus Clarke.
Bellerophon sp. nov.
Leptodesma cf. *Lichas* Hall.
Leiopteria lævis Hall.
Grammysia sp. nov., of the general expression of *G. subarcuata* Hall.
Macrodon sp.
Nucula, cf. *diffidens* Hall.
Palæoneilo muta Hall.

Unguilina suborbicularis Hall. This abundant shell is very variable. In a large number of finely preserved individuals, it appears that the nearly bilateral form with quite sharp concentric lines represented in the typical example, is of rare occurrence. Such forms sometimes show fine radiating lines and are connected by a normal series with shells in which the body of the valve is oblique and the surface frequently rugose from concentric growth-lines. The genus of this fossil is evidently not *Unguilina*, probably neither *Cardiomorpha* nor *Edmondia*. The shells described by H. S. Williams (Bull. No. 10, U. S. Geol. Surv.) as *Lucina wyomingensis* and *L. varysburgia*, from this horizon in Genesee county, I am unable to identify from the figures and descriptions. There are before me 30 excellent preserved individuals of a species evidently congeneric with these (but by no means *Lucina*). They are probably ident-

ical with one or both of Mr. Williams' species.

Lunulicardium ornatum Hall, (*L. pinnatum* Hall.)
Lunulicardium fragile Hall.
Lunulicardium læve Williams.
Lunulicardium sp. nov. (a)
Lunulicardium sp. nov. (b)
Lunulicardium sp. nov. (c)
Cardiola (*Buchiola*) *retrostriata* Von Buch.
Cardiola Doris Hall.
Cardiola sp. nov.
Pholadella sp.
Lingula triquetra Clarke.
Lingula ligea Hall.
Lingula spatulata Vanuxem.
Orthothetes arctostriata Hall.
Chonetes scitula Hall.
Strophalosia sp.
Aulopora annectens Clarke.
Melocrinus clarkii Williams.

From the lists given it is evident that the fauna of the Naples beds is the reapparition under more favorable conditions, of the assemblage appearing first in the Styliola layer of the Genesee shales. The important characteristics of the fauna as a whole, are

1) the prevalence and variety of goniatites;

2) the great numerical development of *Cardiola retrostriata;*

3) the abundance and variety of species of the genus *Lunulicardium.*

4) the frequent occurrence of certain species of coniferous woods.

It is hardly necessary in this place to enter into an elaborate comparison of the Naples fauna with the various developments of the Intumescens or Goniatiten-kalk fauna in the old world, in Devonshire, Brittany, Belgium, Westphalia, the Hartz, the Styrian and Carinthian Alps, the Urals, etc. With all these occurrences there will be found many features in common, and it may be assumed that the student of palæozoic faunas is more or less familiar with the published discussions of these faunas.

In the Naples fauna there is a noteworthy feature in the total absence of trilobitic remains which are usually present, though not abundant in its transatlantic manifestations; and in the presence of phyllocarid crustaceans, which are not elsewhere known at this horizon. On the other hand not only the predominant elements of the fauna but the generic association throughout, and the expression of the component species, is in precise harmony

with the composition of this lower Upper Devonian fauna elsewhere. At Martenberg, near Adorf, Westphalia, the Intumescens fauna has a peculiar expression from the great abundance of species of *Lunulicardium*. This feature is one rarely developed and in this respect the Martenberg and the Naples fauna are most closely similar, while a general agreement prevails in the other elements of the associations. The Martenberg fauna has been most carefully elaborated by Dr. E. Holzapfel* and while the number of species is greater than in the New York fauna, the points of direct comparison may be indicated as follows :

Goniatites Simplices.	
G. retrorsus von Buch.	cf. *G. uniangularis.* / G. *bicostatus.*
Goniatites Irregulares.	
G. multilobatus Sandberger.	cf. *G. chemungensis*, var.
Goniatites Primordiales.	
G. intumescens Beyrich.	*G. intumescens.*
?*G. carinatus* Beyrich.	cf. ?*G. sinuosus.*
G. tuberculatus Holzapfel.	cf. *G.* sp. nov.
G. forcipifer Sandberger.	cf. *G.* sp. nov.
Orthoceras subflexuosum Münster.	cf. *O.* sp. nov.
O. vittatum Sandberger.	cf. *O. filosum.*
O. acuarium	cf. *O. pacator.*
Holopella arcuata Holzapfel.	cf. *Loxonema noe.*
Marcrochellus dunkeri Holzapfel.	cf. *Macrocheilus* sp. nov.
Pleurotomaria falcifera Sandberger *P. globosa* Holzapfel *P. tenuilineata* Holzapfel.	cf. *P. itys* var. *ten uistriata.*
Natica adorfensis Holzapfel.	cf. *Platystoma* sp. nov.
Cardiola retrostriata von Buch.	*C. retrostriata.*
C. subradiata Holzapfel. *C. inflata* Holzapfel.	cf. *C. doris.*
Mytilarca beyrichi Holzapfel.	cf. certain variations of *Lucina*?? *suborbicularis.*
Lunulicardium mülleri Holzapfel. *L. cancellatum* Holzapfel.	cf. *L.* sp. nov.
L. bickenense Holzapfel. *L. inflatum* Holzapfel.	cf. *L. læve.*

A comparsion like this can only serve to indicate, and that imperfectly, similarities, which in some cases may prove specific identities, while interesting and important points of agreement in other species may not even be suggested.

The species *Cardiola retrostriata* von Buch* (*Buchiola*, Barrande, *Glpytocardia*, Hall) makes its appearance in New York as in Europe in the earlier Devonian. It is found as low, though very rarely, as the black shales of the Marcellus division. The late

*Palæontographica, Neue Folge, vol. viii, 6, xxviii.

professor Von Seebach cited *Cardium palmatum* Goldfs, (= *C. retrostriata* Von Buch) from the Wissenbacher (Goslarer) schiefer of the Hartz, and F. Maurer, in "Die Thonschiefer des Ruppbachthales bei Diez"* describes a form very similar to *C. retrostriata* from the Wissenbacher-schiefer of the Rhine.* Barrande has also cited it from a still earlier horizon, his etage E, as he does also from the higher etage H, which may be nearer the plane of its normal maximum development in other faunas. Barrois has shown that the shales described by Casiano de Prado† as the "Schistes à *Cardiola retrostriata* de la Collada de Llama," in the Province of Léon, Spain, are of equivalent age to the Wissenbacher-schiefer of the Rhine.‡

This identification is of much interest on account of the close similarity of the fauna of these black shales and the normal fauna of the Marcellus black shales. The black *Cardiola retrostriata* shales are described as "fins, ampéliteux et argilo-ferrugineux." They have furnished but few species:

Phacops latifrons Bronn,	cf. *Ph. rana* (Marcellus shales)
Goniatites cf. *occultus* Barrande,	cf. ? ? *G. discoideus* "
Orthoceras regulare Schlotheim,	cf. *O. subulatum* "
Bactrites schlotheimi Quenstedt,	cf. *B. clavus* "
Pleurotomaria subcarinata F. A. Roemer	cf. *P. rugulata* "
Posidonomya pargai de Verneuil,	cf. *Pterinea laevis* Goldfs. var. *americana* d'Orbigny (Marcellus shales)
Cardiola retrostriata von Buch,	idem.
Retzia novemplicata,	cf. ? *Leiorhynchus limitaris* (Marcellus shales).

Its horizon of maximum and characteristic development, however, wherever the specialization of the component elements of the upper Devonian faunas is more pronounced is below the normal horizon of *Spirifer disjunctus* and above that of *Rhynchonella cuboides*. It is a usual member of the Intumescens fauna, but it is present at this horizon when the goniatite facies is wanting. In the north of France and on the Belgian frontier the "Schistes à *Cardium palmatum*" are assigned the following position by Gosselet.§

Schistes de Famenne, with *Spirifer disjunctus*, *Rhynchonella pugnus*, *Productus subaculeatus*; also *Rh. cuboides*.

Schistes à *Cardium palmatum*, with *Goniatites retrorsus*.

Schistes à nodules argilo-calcaires, with *Rh. cuboides*, *Atrypa reticularis*, *Spirifer euryglossus*.

---

*Neues Jahrbuch für Min. 1876, p. 25.

†Note géologique sur les Terrains de Sabero et de ses environs dans les montagnes de Léon (Espagne); Bull. Soc. géol. France, 2d ser. tom vii, p. 137, 1850.

‡Note sur le Terrain dévonien de la Province de Léon (Espagne); Assoc. Franc. pour l'Avancement des Sciences, 1877.

§Annales des Mines, ser. 6, tom xii, p. 595, 1867.

In 1878 the same author gave the same order of succession, showing that the Schistes à *Cardium palmatum* occupy a distinct horizon between the Frasnien, or Cuboides limestone, and the Faménnien or the normal horizon of *Spirifer disjunctus.** In other words, in this section, they occupy the position of the Goniatite or Intumescens fauna, and in absence of the latter in its fuller development, represent it.

In the Domanik-schiefer of the Petschora Land,† the Iberger-kalk of the Hartz,‡ the shales of Torbay,‖ and of Lower Dunscombe,§ in Devonshire, it is coexistent with the goniatite facies of the Intumescens fauna.

On the continent of Europe the faunas of the lower Upper Devonian are variable in facies. In the classical Eifel section immediately above the niveau of the Stringocephalus limestone or the middle Devonian, the brachiopod facies prevails (the Cuboides-schichten), followed above by the typical Goniatiten-schichten, abundant in Goniatites Simplices. In the region about Aachen the brachiopod or Cuboides facies is again strongly developed and the predominance of the brachiopod element is continued through the overlying beds, the Verneuili-schiefer and Verneuili-sandstein of Kayser. Here the cephalopod facies is again virtually wanting or insignificantly developed. In Westphalia, at Bredelar in the vicinity of Brilon, and at Adorf, the goniatite beds of the middle Devonian are directly overlaid by the goniatite limestone of the Intumescens zone. According to Kayser, the upper Devonian of this region is divisible into the lower zone ("Intumescens") and an upper, which he has termed the "Münsteri zone;" and the latter is again divisible into the "Cypridinen-schiefer" below and the "Clymenien-schichten" above.

In the Iberg-Winterberg terrain of the Hartz we have a remarkable faunal association; an unlaminated *massif* contains not only the index fossils of the Cuboides and Intumescens zones, but an actually predominating number of middle Devonian species; in other words, it appears to be an encroachment upon a middle Devonian fauna, of faunas of later date, the facies of which, usually differently developed elsewhere, are here still undifferentiated.

*Bigby's Thesaurus Devonico-Carboniferus, p. 122.

†Keyserling, Eine Reise in das Petschora-land, p. 254, 1846.

‡Clarke, Fauna des Iberger-kalks; Neues Jahrb. 1884, Beil. Bnd. iii, p. 380.

‖Lee, Geological Magazine, new ser, vol. iv, p. 100, 1877.

§Ussher Quart. Journ. Geol. Soc. vol. xlvi, p. 506, 1890.

In the Ural mountains the phenomena are similar in many respects to those of the Iberger-kalk. Tschernyschew says:* "The strata D$\frac{1}{3}$, characterized by the prevalence of limestone, with some bituminous layers and sandstone, abound in places in brachiopods which distinguish the Cuboides beds of the Eifel and Belgium; in some localities, however, there are goniatites in great numbers belonging to the group of the Primordiales and other forms somewhat common in the goniatite strata of western Europe. In many cases this formation includes a great number of forms characteristic of the Iberger-kalk, where, according to Kayser and Clarke both the brachiopod and goniatite facies are represented."

Without citing further phases of the lower Upper-Devonian fauna, enough has been given to show that the terms Cuboides zone, Goniatite zone and Intumescens zone are, in a broad sense, essentially equal time values and only expressions of varying phases or facies of equivalent faunas.

The Intumescens zone in its best development, perhaps in Westphalia, is a horizon of limestones, it is therefore a noteworthy fact that there should exist so great a similarity in composition between the limestone fauna of Martenberg (Adorf) and that of the shaly and sandy sediments of western New York.

The Tully limestone of New York has been long regarded, especially by European writers, as the equivalent of the Cuboides fauna of the lower Upper Devonian. It is usual to find throughout European literature, in discussions upon the comparative value of these faunas and in comparative lists of species, this Tully limestone referred to the base of the Upper Devonian. The writer has himself thus referred to it on several occasions.† This is not the position in the geological scale to which it has been assigned by professors Hall, Dana and the American geologists generally. This limestone is the American horizon of *Rhynchonella cuboides* (as identified by Conrad in 1842, *R. venustula* Hall, 1867), but this species is the sole distinctive representative of the Cuboides fauna in a fauna otherwise essentially of middle Devonian age. The case is not parallel to that of the Iberg limestone fauna; in the latter the middle Devonian element,

*Die Fauna des mittleren und oberen Devon am West-abhange des Urals, p. 10, 1887.

†Die Fauna des Iberger-kalkes, p. 385. Forty-second Ann. Rept. N. Y. State Museum, p. 405, 1889. See also Palæontology of New York, vol. vii, p. 13.

though preponderating in actual number of species, is a far less percentage of the index fossils of the middle Devonian than the upper Devonian species there are of typical upper Devonian faunas. Until quite recently no very detailed study of the Tully fauna had been made, but in a late paper it has been discussed at some length by Mr. H. S. Williams of Ithaca.* Mr. Williams has adduced considerable new data without however elucidating the character of the entire fauna as known to-day. Conceding the well-known fact that the great majority of the species are those of the preceding fauna of the Hamilton shales, the author says: "The fauna of the Tully limestone is made up of two groups of species, first those, having closely allied forms in the immediately preceding middle Devonian formations; second, those having closer affinity with European forms than with any species occuring in the lower formation of America." "In the Tully limestone the latter class are few." Of this smaller group the following fossils have suggested to this author points of comparison with species of the Cuboides fauna:

Orthis tulliensis Hall.

This *Schizophoria* is represented in the middle Devonian throughout Europe by the well known *O. striatula* and some allies. It also occurs in the Cuboides fauna of the Eifel and frequently in the Intumescens zone. In America the type of structure exemplified by this species dates as far back as the middle Upper Silurian and becomes more or less abundant throughout the Devonian, but this species itself, as Mr. Williams has very accurately said, has a stability of form which is not manifested by its successors *O. impressa*, *O. iowensis*, *O. macfarlanii*; a feature in which it agrees with the earlier Devonian, *O. propinqua*, of the Corniferous limestone. It would puzzle an expert student to point out differences of even varietal value between the Corniferous and Tully forms, and a palæontologist better familiar with the European than with the American Devonian would certainly refer without hesitation both to *O. striatula*. In the Hamilton fauna of New York, *O. Tulliensis* is not known to occur, but in the cement beds about Milwaukee it appears in association with a strongly emphasized Hamilton fauna. This fauna has been described by Mr. R. P. Whitfield† though the species in question has been referred by him to *O. impressa*.

*The Cuboides Zone and its Fauna; A discussion of methods of correlation. Bull. Geol. Soc. Amer. Vol. I, pp. 481-500, pls. 11-13, 1890.

†Geology of Wisconsin, vol. iv, p. 324 *et seq.*

Wisconsin is one of the areas where the life of *O. propinqua-tulliensis* was continued into association with a typical Hamilton fauna. There *Rhynchonella cuboides-venustula* is absent, but the reappearance of *O. propinqua-tulliensis* in the Tully limestone is quite as likely due to its return eastward as to an immigration from the east. We do not follow Mr. Williams in the statement that "Its appearance in the following zone in New York, i. e., the Ithaca formation and the High Point fauna in Ontario county, suggests that the fauna to which it belongs is more directly associated with what follows than with the New York Hamilton fauna" (p. 492). The High Point species is not a *Schizophoria* of this rigid specific type but is susceptible to very considerable variation and is more nearly like the form described by Meek as *O. Macfarlanii.* Moreover neither the Ithaca formation nor the High Point fauna constitutes the zone next following the Tully limestone in New York.

Strophodonta perplana Conrad (sp.) var. *tulliensis* Williams.

The author makes an evidently good separation of a small form of this species with mucronate cardinal extremities, but the correlative importance given to the variation is far overwrought. He says (p. 493): "The second species, *S. perplana* var. *tulliensis*, is a mutation (*sic*) of the race which begins in *Strophomena alternata* in the Trenton stage." Undoubtedly *Strophomena alternata* is a representative of the stock from which the strophodontoid line emanated, but the "race" did certainly not have its beginning in this Trenton species.* Attention is called to the fact that at the base of the Devonian the "race," referred to develops into two "races" (p. 493), one a thin flat form, typified by *S. perplana* Conrad, which is said to be "an American type and is seen with variations all through our Devonian, but it is not described in the European Devonian." Nevertheless the type is well known in the European Devonian and is represented by *Strophomena explanata* Sowerby, as identified by Kayser who states that it is known to him from all horizons of the Rhenish lower Devonian and is nowhere especially rare.†

The other "race," which is really the normal line of strophodontoid development, maintains the convexo-concave contour. "This is the *Orthis interstrialis* Phillips, of the European Devonian and *Strophomena inæquistriata* Conrad, of the New York

***Leptæna incrassata* and *L. fasciata* Hall, of the Chazy limestones are species congeneric with *Strophomena alternata*.

†Die Fauna des Hauptquartzits, p. 102, 1889.

Hamilton. The *interstrialis* race is recognized in our Chemung *Strophodonta cayuta* and in the upper and middle Devonian of Europe and the east in *Strophomena dutertrii* and *S. aselli.*" It is, however, a fact that *S. inæquistriata*, *S. cayuta* and *S. dutertrii* represent a subordinate type of structure which has been designated by Œhlert with the term *Douvillina*. Whether *S. interstrialis* and *S. aselli* belong to the same group we have no definite evidence. It is further stated that in the European "race" (referring to the convexo-concave strophodontoids,) the terminations of the hinge develop into slender, mucronate points; that in the American "race" (the flat group?) "these mucronate points *first* appear in the Tully limestone forms and are characteristic of the race afterward till it ceases. The representatives of this (mucronate) type of *Strophomena* are common in Europe throughout the Devonian, going under the specific names *interstrialis*, *aselli* and *dutertrii*, and the conspicuous development of the mucronate points did not appear till about the stage of the appearance of *Rhynchonella cuboides.*" This argument is not a forcible one; it is weakened, in the first place, by being based on distinct subordinate types of generic structure, and further, we might cite *Strophodonta junia* Hall, of the Hamilton group as an example of a species which frequently shows mucronate cardinal extremities, and to go back to the inceptive forms of the strophodontoid type, *S. leda* Billings, has these extremities strikingly developed, and this is a form which differs no more widely from *S. demissa*, the type of the genus *Strophodonta* than do the subordinate types of *S. perplana* and *S. dutertrii.* The species *Strophomena armata* and *S. stephani* Barrande, from the etage F., are strophodontoids withe xtended cardinal angles.

It is upon these two forms, *Orthis tulliensis* and *Strophodonta perplana*, var. *tulliensis*, together with *Rhynchonella cuboides-venustula*, that the correlation of the Tully with the Cuboides sone is based. One other direct comparison is instituted between the Tully snd the Cuboides species. In reference to *Bronteus tullius* Hall, it is said that it "is closely allied to a form of the European Cuboides zone (*B. flabellifer* Goldf)." But *B. Tullius* belongs to the subgenus *Thysanopeltis* (with spinous pygidial margin) and *B. flabellifer* does not.

It does not appear that there is much reason for regarding the correspondence of the Cuboides fauna and that of the Tully as greatly fortified by this evidence. The bond between the two is

undoubtedly what it has long been known to bé, viz.: the coëxistence of *Rhynchonella cuboides*. The accuracy of regarding the Tully as the time-equivalent of the Cuboides fauna, even though it were by virtue of this fact alone is, of course, beyond contravention.

Another significant feature in the correlation of the New York Intumescens fauna is the abundance of certain species of coniferous woods. These are of much more frequent occurrence in the first appearance of the fauna, than in its reappearance, one species, described by Sir William Dawson as *Dadoxylon clarkii*, being very common and occasionally appearing in the Naples beds above. Sir William has also identified the species *D. newberryi* Dawson, and *Cladoxylon mirabile* Unger, from the Styliola layer. The last of these species was described from the Cypridinen-schiefer (Entomiden-schiefer, T. R. Jones) of the Thuringian Forest (Saalfeld)* and identified by Dawson in 1882.† In a recent paper‡ on these fossil woods Sir William says in regard to the species *D.* (*Cordaioxylon*) *clarkii* (p. 243); "I may now add that the species is very near to *Araucarites ungeri* of Gœppert, from the Cypridinia shales of Thuringia. This species appears to be the same with that originally described by Unger as *Aporoxylon primigenium*. The original description and figures of Unger did not permit an exact comparison, but as now figured by Stenzel in his revision of Gœppert's species, it approaches so near to *D. clarkii* as to suggest the suspicion that it may be the same or a very closely allied species."

In the same paper professor Penhallow discusses at some length finely preserved specimens of *Kalymma grandis* Unger (the original also from the Cyprindinen-schiefer at Saalfeld), from the Black Shale of Moreland, Kentucky, a horizon which, though little studied, will probably prove equivalent to that of the Styliola layer.§

These woods introduce an interesting element into the association of fossils of the Intumescens zone, seeming to indicate a more rapid migration of the terrestrial flora which characterized the

*Beitr. zur Paläontologie des Thüringer Waldes, Zweiter Theil, p. 93, pl. xii, figs. 6, 7. 1856.

†Fossil Plants of the Erian and Silurian of Canada, pt. ii, p. 126. 1882.

‡Notes on Specimens of Fossil Wood from the Erian (Devonian) of New York and Kentucky, by Sir William Dawson and Prof. D. P. Penhallow; Canadian Record of Science, vol. iv, January, 1891.

§Dr. C. E. Beecher, who collected the specimens of *Tralymma grandis* referred to, informs the writer that *Goniatites intumescens* occurs in the same rocks.

middle Upper Devonian of Europe, than of its marine fauna. Nevertheless, it may be observed that the fauna contains an undescribed species of Goniatites not far from *G. muensteri* and an *Entomis* allied to *E.* (*Cypridina*) *serratostriata*,, both of which characterize the upper zones of the Devonian in Westphalia.

In conclusion it may be said that we have in the Upper Devonian of western New York, at the base, in the Tully limestone, a sparsely represented time-equivalent of the Cuboides zone (brachiopod facies); this is followed by an abundant development of a normal Intumescens fauna, involved in shales which bear to a greater or less extent a fauna of a local or indigenous character. This Intumescens fauna or cephalopod facies of the lower Upper Devonian, includes certain elements at a maximum development (*Cardiola retrostriata*, coniferous woods) which in the European succession, frequently occupy distinct horizons below and above the normal horizon of the Intumescens zone.

ON A PECULIAR FORM OF METALLIC IRON FOUND IN HURONIAN QUARTZITE, ON THE NORTH SHORE OF ST. JOSEPH ISLAND, LAKE HURON, ONTARIO.*

By G. Christian Hoffman, F. Inst. Chem., Chemist and Mineralogist to the Geological and Natural History Survey of Canada.

In the course of examining some surface specimens of quartzite[1] from the north shore—fifth concession, back of Campement d'Ours—of St. Joseph Island, it was observed that certain faces, apparently fissure surfaces, of the same, were coated with a thin deposit of dark reddish-brown limonite through which was disseminated numerous metallic looking spherules, thereby imparting to it an oolitic structure. In the specimen which best showed its mode of occurrence, this deposit formed a layer, on one face, of from one to one and a-half millimetre in thickness, and this, judging from the appearance of the exposed surface of the same, which showed indications of having been a contact surface, may perhaps be fairly assumed to represent the diameter of the original fissure. Running parallel to and in direct communication with the latter was a gouge-shaped groove measuring where it

*From the Transactions of the Royal Society of Canada, vol. viii, 1891.

[1]A greyish, in parts greenish and brownish coloured quartzite, with here and there an inclusion of white vitreous quartz, and red and blackish or brownish black jasper.

opened into the fissure, its widest part, five millimetres across, and having a varying depth of from five to six millimetres. This groove, retaining these dimensions, extended right across the face of the specimen, which face, in this direction, measured four centimetres. There was nothing to indicate what the probable length of this groove may have been, as it occurred in the rock, in situ, or whether it occupied a vertical, horizontal, or intermediate position, although conjecture might perhaps, in this particular instance, favour the former view. It was closely packed with material of precisely the same character as that contained in the fissure, the material of the one forming an uninterrupted connection with and, as it were, extension of, that of the other, so that we may indifferently regard the material in the fissure as an overflow from the groove, or that in the latter, more especially if this merely represented an elongated cavity, as a filling in from the former.

No metallic grains or matter likely to have resulted from the alteration of the same, or mineral from which the iron could possibly have been derived, was observable in any other part of the specimens examined.

The material which, as already remarked, had an oolitic structure, was dense in texture and firmly adherent to the face of the quartz. It was found to be made up of:

Metallic grains	58.85
Limonite	39.73
Siliceous matter	1.42
	100.00

The siliceous matter consisted of angular particles of quartz which had evidently been chipped off with, and remained attached to the material when removing it from the rock.

The metallic grains varied greatly in size, the largest not exceeding thirty-seven hundredths of a millimetre in diameter, whilst many, perhaps the greater number, were of far smaller dimensions, and others were of microscopic minuteness. Although diverse in form yet all were rounded and, for the most part, more or less spherical in shape. They were strongly attracted by the magnet and after separation by its aid from the associated non-metallic matter, aggregated themselves into loose bunchy masses or formed trains. Brittle—in the process of pulverization emitted a faint yet distinct phosphorretted odour. Colour of freshly fractured surface of metal, steel-grey. When immersed

in a solution of cupric sulphate the grains became immediately coated with a film of metallic copper. They were readily attacked by hydrochloric acid with evolution of hydrogen possessing a marked odour of phosphine, the latter, however, gradually passed off as digestion proceeded, when a peculiar fetid smell similar to that which characterizes hydrogen evolved from wrought iron or impure zinc, was observable. Hydrochloric acid did not effect complete solution—the undissolved material still presenting a metallic aspect; a further treatment with nitric acid, however, removed the remaining metallic matter, leaving a granular, nucleiform, non-metallic, insoluble residue.

The metallic spherules were found to have a specific gravity, at 15.5° C., of 6.8612, and a composition, as follows:

Iron	88.00
Manganese	0.51
Nickel	0.10
Cobalt	0.21
Copper	0.09
Sulphur	0.12
Phosphorus	0.96
Carbon	?
Organic matter	undet.
Insoluble, non-metallic, residue	9.76
	99.75

The insoluble residue consisted of spherical, ovoid, etc., shaped grains which were more or less coated with a yellowish-brown, apparently humus-like, substance. When broken, these spherules were seen to have a concentric structure, apparently of a concretionary character. On ignition the organic matter readily burnt off, leaving them snow-white. The ignited spherules were found to be exceedingly hygroscopic, so much so, that in the short space of time occupied in their transference from one container to another, they absorbed not less than 0.775 per cent. of water.

An analysis of this residue gave the following results:

Silica	9.17
Alumina	0.11
Ferric oxide	0.10
Lime	0.06
Magnesia	0.03
Loss?[1]	0.29
	9.76

[1]The analysis was conducted upon a very small amount of material—the silica may, not improbably, be a little too low.

Hence, the centesimal composition—of the metallic portion of the spherules, would be:

Iron	97.79
Manganese	0.57
Nickel	0.11
Cobalt	0.23
Copper	0.10
Sulphur	0.13
Phosphorus	1.07
Carbon	?
	100.00

and that of the insoluble, non-metallic, residue;

Silica	93.95
Alumina	1.13
Ferric oxide	1.02
Lime	0.62
Magnesia	0.31
Loss?[1]	2.97
	100.00

The limonite did not contain any, so to say, denuded nuclei, so that supposing it to have resulted from the weathering of the metallic spherules, the change had in no instance proceeded so far as to effect the removal of the whole of the metallic covering. Some of the nuclei were of microscopic minuteness, hence it may be inferred that even the smallest of the metallic spherules contained a siliceous nucleus. The limonite gave no reaction for chlorine.

From what has preceded it will be seen that the metallic looking spherules which were disseminated through the limonite, consisted of nuclei of silica coated with a humus-like substance which in turn, was overlain by a metallic layer, the latter containing all the elements most frequently met with in meteoric iron. The amount of phosphorus is relatively large, that of the nickel, however, very small, consequently if it be regarded as present in the form of any of the varieties of nickel-iron or schreibersite, it would represent but comparatively trifling amounts of either of these bodies.

Owing to the fact that all meteoric iron contains nickel, the presence of that element in a native iron has generally been regarded as evidence of its extra-terrestrial origin and for this reason the irons of Chotzen and Petropaulwosk although sometimes

[1]The analysis was conducted upon a very small amount of material—the silica may, not improbably, be a little too low.

FIG. 1. FIG. 2.

FIG. 3. FIG. 4.

TO ILLUSTRATE MR. G. C. HOFFMAN'S PAPER ON A PECULIAR FORM OF METALLIC IRON.

mentioned in connection with those of accepted telluric origin[3] are, in consideration of their having been shown to be nickeliferous, referred to by some authorities as most probably of meteoric origin. It will be remembered, however, that the native iron of Ovifak, Disco Bay, Greenland, which was at first regarded by the discoverer, Nordenskiöld, and others as meteoric iron, also contains a certain amount of nickel, yet the observations of Steenstrup, Törnebohm and Smith, make it very certain that the iron is not meteoric but of terrestrial origin, in which case the presence of nickel in an iron would not have the same significance as it was formerly supposed to have.

Assuming, therefore, that the trifling amount of nickel present in this iron would not necessarily imply a cosmic origin, the relatively large amount of phosphorus accompanying the nickel, the presence of organic matter[1] and the fact of the spherules containing nuclei, apparently of a concretionary character, would suggest the possibility of this iron having a terrestrial source, upon the assumption that it has resulted from the reduction of an iron-salt by organic matter, in which case it would have a community of origin with the sideroferrite[2] of Bahr.

I am indebted to my friend Dr. A. P. Coleman for the skillfully executed water-colour sketches from which the accompanying plate has been prepared. These will serve to convey a far more accurate idea of the material under consideration than any mere verbal description of the same possibly could.

EXPLANATION OF PLATE.

Fig. 1. Shows mode of occurrence of the material in the rock—Natural size.

Fig 2. Illustrates two of the most prominent forms of the metallic spherules—Magnified 85 diameters.

---

[3]Such as the iron found by Andrews in basaltic rocks from the Giant's Causeway, and that found by Mossier in lava from Graveneire in Auvergne.

[1]The presence of organic matter of the nature (humus-like) of that here referred to would not appear to be inconsistent with an extra-terrestrial origin. The meteorite of Alais contained a carbonaceous matter which Berzelius considered might not improbably be humus. Wöhler found the carbonaceous matter of the Kold-Bokeveldt and Kaba meteorites to consist of a mixture of amorphous carbon and bituminous matters, described as not unlike Scheererite or Ozocerite. Cloez again, found the carbonaceous matter of the Orgueil meteorite to resemble, both in appearance and composition, certain humus substances.

[2]A native iron found by Bahr, in the form of grains, thin laminae and powder, in a fragment of mineralized wood—resembling bog-ironore in appearance—from a floating island in the Ranlanger Lake in Smaland, Sweden.

Fig. 3. Shows diversity of form of the metallic spherules and disposition of these to form trains—Magnified 25 diameters.

Fig. 4. Exhibits form and structure of the siliceous nuclei (the largest of these having been selected)—Magnified 25 diameters.

EDITORIAL COMMENT.

The Crenitic Hyphothesis.

It must be highly gratifying to the author of this work* that after so short an interval as four years, he is called to issue a second edition, for it deals with some of the most advanced problems of chemical and speculative geology, and is in demand only by those working geologists whose labor is in the Archean rocks.

The most important part of this volume is that which treats of the origin and genetic history of the crystalline rocks, occupying chapters V and VI. From his long-continued chemical and mineralogical studies in the geognosy of the crystalline rocks Dr. Hunt derived the "Crenitic hypothesis" of their origin. He shows that none of the hypotheses that had been proposed fully satisfied the conditions of the problem of their origin.

There are six theories which he rejects. (1.) That which he styles *endoplutonic* and which supposes the crystalline rocks to have been formed from the mass of the primeval globe as it congealed from igneous fusion, he shows, as remarked by Naumann, requires a progressive consolidation from the surface downward. This order is the reverse of that which has been established for the normal succession in the growth of the crystalline rocks. In many parts of the world observers concur in the statement that these rocks are newer in ascending order, and gradually assume, through the so-called *transition* strata, the physical characters of the uncrystalline and sedimentary rocks.

(2.) The *exoplutonic* theory conceives the crystalline stratiform rocks to have been formed from volcanic ejectamenta from beneath the superficial crust of the earth. This includes, besides lavas and pyroclastic rocks, the ordinary products of volcanoes, according to some of its adherents, also hydrated serpentinic and

**Mineral Physiology and Physiography; a second series of Chemical and Geological Essays*, T. Sterry Hunt. Second Edition, with new preface. Octavo, 710 pp., Scientific Publishing Company, New York, 1891.

feldspathic magmas, and even quartz, magnetite, limestone, rock-salt, anhydrite and some clays and sands. To this he states there is no evidence in the lithological character of these rocks of their volcanic origin. And that the universality of their distribution and unity of characters, as well as the thoroughly crystalline character of the gneiss, are incompatible with this idea.

(3.) The *metamorphic* hypothesis would derive the primitive strata from the consolidation and the recrystallization of detrital plutonic rocks, or at least from rocks derived from the destruction of other older rocks, the debris from which had been laid down in the bottom of the sea as sediments. The enormous thickness of the primitive strata, at least 30,000 feet, and their world-wide extent renders it inconceivable that any older lands could have existed capable of furnishing this amount of material by any such process. Again the crystalline condition of the gneiss is so perfect that it bears slight resemblance to any rock known to have been formed by such consolidation from sediments; and all examples of reputed metamorphic rocks like those of the primitive strata, of secondary or tertiary age, have, on careful examination, been found to be based on wrong observation.

(4.) The *metasomatic* hypothesis postulates the formation of vast deposits of limestone and their subsequent conversion into gneisses and schists by slow chemical replacement. This has for its basis the occasional observed association of some silicates with calcite and their substitution for it. The author regards this hypothesis as a gratuitous one, and says that it "would make as great a demand on our credulity as the metamorphic hypothesis itself."

(5.) The *chaotic* hypothesis, of Werner, which supposes that all the materials of the crystalline rocks were originally dissolved in a primeval sea, and were successively deposited in crystalline form from it, meets with insurmountable chemical difficulties, the chief of which is the inconceivableness of any conditions by which all these elements could have been held in solution by the ocean at any one time. This idea, successfully urged by Playfair and his followers, "contributed to the discredit which fell upon the Wernerian hypothesis."

(6.) The theory of Daubrée, the *thermo-chaotic* hypothesis, requires that the first oceanic waters be hot, and thus able to exert a powerful solvent action upon the previously formed plutonic rocks of the primitive crust, transforming them into the present crystalline stratiform rocks. These waters were condensed upon

the primeval surface under a pressure estimated to be equal to 250 atmospheres, corresponding to a temperature near that of redness. This process Hunt regards as prior to that in which the actual crystalline rocks were formed, their mineralogical characters and associations being incompatible with the elevated temperature supposed. This early history was but a preparation for the generation of the crytalline schists, whose temperatures must have been such as to allow the existence of organic forms, evinced by *Eozoon*, by limestones, quartzytes, carbon, etc.

These difficulties show that no previous hypothesis meets all the conditions. The author therefore proposes the *Crenitic Hypothesis*.

In the author's mind this hypothesis has been a gradual growth, its various stages of advance being recorded in his successive published papers, since 1858. It "conceives the crystalline rocks to have been derived, directly or indirectly, by solution from a primary stratum of basic rock, the last congealed and superficial portion of the cooling globe, through the intervention of circulating subterranean waters, by which the mineral elements were brought to the surface. * * * The cooling of the surface of the earth by radiation, and the heating from below, would establish in the disintegrated, porous and unstratified mass of the primary [basic] layer, a system of aqueous circulation, by which the waters penetrating this permeable layer would be returned again to the surface as thermal springs charged with various matters, there to be deposited. The result of this process of upward lixiviation of the mass would be the gradual separation of the primary, undifferentiated layer into an upper stratum, consisting chiefly of acidic silicates, such as feldspars with quartz, and a lower, more basic and insoluble residual stratum charged with iron oxide and magnesia, the two representing respectively the overlying granitic and the underlying layers, the presence of which beneath the earth's surface has generally been inferred from exoplutonic phenomena."

The fundamental fact of this hypothesis is the formation, by aqueous secretion, of zeolitic minerals in the cavities of basic eruptive rocks. This is pursued in its ramifications and modifications until it is found that orthoclase, quartz, albite, amphibole, garnet, epidote, magnetite, hematite, native copper, native silver, and in fact nearly all the minerals that are found in the gneisses or in schists, and many others, are explainable by aqueous secretion from basic plutonic rocks.

The argument is pushed to its conclusion with a wealth of il-

lustrations and a redundance of chemical interpretations which have made Dr. Hunt's writings unique in American geological literature. Among other facts he quotes the remarkable discovery of Murray and Rénard, viz : that a decomposition of volcanic detrital material goes on at low temperatures in the depths of the ocean, transforming basic silicates, represented by volcanic glasses, such as hyalomelane and tachylite, into a crystalline zeolite on the one hand, and the characteristic red clay of deep-sea deposits on the other. This goes on at a temperature approximating zero, centigrade.

As a theory the "Crenitic hypothesis" is well set on its legs. It has to undergo yet the fire of innumerable criticisms and the counteracting effect that may come from a more perfect knowledge of Archean stratigraphy itself than is evinced by the author. There is great diversity in the Archean rocks, and yet a grand progression in their general lithologic aspects. A stumbling-block which the theory will encounter at once is its "sweeping" scope. The Archean rocks are all subjected to its single operation. That has been the trouble with all former hypothesis. They have been based on partial evidence. All these rocks have been thrown together in a lot, and if a part of them have been found explainable by any observed process, that has furnished foundation to explain them all. It will meet with another obstacle in the fundamental assumption that the supposed crenitic circulation of water in early Archean time would in the first instance, bring siliceous elements in solution to the surface, and would reject the basic elements. In the scale of solubility silica ranks very low among the natural minerals, and it is questionable whether natural waters would prevailingly take it into solution to the neglect of the others. Would not the order be the reverse from that supposed ? Would not the natural effect be the rejection, as a whole, of the more insoluble siliceous elements, and the removal of the basic by solution ? Is it not *after* water has first become charged with alkalinic or other solvents that it attacks silica and carries it in solution ? Is it not true that the characteristic elements of the supposed residual stratum, (iron-oxide and magnesia) are themselves more soluble than the characteristic elements of the supposed crenitic stratum and hence that they would be brought sooner to the surface ?

The hypothesis starts out with a statement of what appear to be contradictory postulates, viz : First, the primitive basic stratum is said to be "the last congealed and superficial portion of a cooling

globe," leaving us to suppose that the lower portions were cooled and congealed earlier, yet the circulation of the crenitic water is instituted and maintained by the "cooling of the surface by radiation and the heating from below."

The "greenstones" form the uppermost member of the pre-Taconic crystalline rocks. They are characterized by their resemblance to the supposed "residual stratum," i. e., they contain in abundance the "insoluble oxide of iron and magnesia." The author supposes, in partial accordance with the latest deductions, that these rocks are the result, first, of exoplutonic extravasation, and second, of the chemical deposition of magnesian silicates from solution derived from the action of waters on this extruded material. There is here apparently another anomalous supposition introduced, in that the action of the surface waters on this basic matter removed the lime and magnesia which are said to pass in solution into the sea, leaving of course the siliceous elements undisturbed or at least not carrying them into the sea. Yet this basic matter is said to have been derived from the supposed "residual stratum" and must hence have been not very much unlike the basic primitive stratum on which the crenitic waters are supposed to have acted with a result almost the reverse.

The author takes but little account of the grand physical structures of the Archean rocks, such as bedding, dip, compression, shearing, schistosity, and the various more minute features which are generally considered as indices of a long physical history and of the agency of mechanical forces in bringing these rocks into their present conditions. The idea of metamorphism from a stratified sedimentary origin is specially denied. The results of late microscopic research into the intimate structures are passed by in silence.

These are some of the obvious difficulties which arise in the mind of the reader who attempts to digest the argument, and are not supposed to be insurmountable objections to the hypothesis—though sometimes hypotheses have been cast aside as worthless on no stronger evidence of inconsistency.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the Nickel and Copper Deposits of Sudbury, Ontario. By ALFRED E. BARLOW, M. A. (of the Geological Survey Dept.) This timely paper, which appears in the June number of the Ottawa Naturalist, deals in

general with the discovery, geological relations, mode of occurrence, and composition of the nickel and copper ores in the Districts of Algoma and Nipissing, together with their preliminary metallurgical treatment as carried on in this district. The discovery of nickel in Canada dates back to 1846, when its existence in workable quantities at the Wallace Mine, on lake Huron, was made known. In 1856, Dr. T. Sterry Hunt in his analysis of some trap collected by Mr. Alex Murray of the Geological Survey from the northwestern corner of the township of Waters, showed that small quantities of nickel and copper were present. These deposits are composed of very intimately mixed chalcopyrite and nickeliferous pyrrhotite. The detection at some of the openings of polydymite, a ferriferous sulphide of nickel, as well as a few undoubted crystals of millerite seems to justify the assumption that in the more highly nickeliferous deposits, at least, the nickel is also present as a sulphide disseminated through the ore mass like the iron and copper. ' These sulphides may be said to occur in three distinct ways:

1st, as contact deposits of pyrrhotite and chalcopyrite situated between the clastic rocks, such as felsites quartzites, etc., and intrusive diabase or gabbro, or between these latter and granite or micropegmatite.

2d, as impregnations of these minerals through the diabase or gabbro which are sometimes so rich and considerable as to form workable deposits. These sulphides are in no case present as disseminations through the clastic rocks very distant from the diabase or gabbro which seems clear evidence that they have been brought up by the latter.

3d, as segregated veins which may have been filled subsequently to the intrusion which brought up the more massive deposits. These veins are not very common although certain portions of the more massive deposits may have been dissolved out and re-deposited along certain faults and fissures.

Assays made for the Canadian Copper Co., by Mr. F. L. Sperry, the chemist, show a range in the percentage of nickel from 1.12 per cent. to 4.21 per cent. with an average of 2.38 per cent., while the copper varied from 4.03 per cent. to 9.98 per cent. with an average of 6.44 per cent. Mr. Hoffmann, of the Geological Survey, assayed four samples which showed the nickel contents to vary from 1.95 per cent. to 3.10 per cent. with an average of 2.25 per cent. The metallurgical treatment commences at the roast where the ore is piled in rectangular heaps on previously laid cord wood and roasted for 50 to 70 days and when thoroughly done should contain about 7 or 8 per cent. of sulphur. It is then smelted in a very perfect water-jacketed furnace, the resulting product or 'matte" containing about 27 per cent. copper and 14 per cent. nickel. This is then packed in barrels and shipped to the various refineries of the United States or Europe according to their respective bids.

The paper in question is the best report we have seen as yet upon the Sudbury region, and no one interested in the geological and mineralogical problem involved, as well as the metallurgical points with which it deals, can be without it.

On the Sequence of Strata forming the Quebec Group of Logan and

Billings, with remarks on the Fossil Remains found therein. By HENRY M. AMI, M. A., F. G. S., etc., of the Geological Survey of Canada.

The above is the title of a paper communicated to the Royal Society of Canada by Dr. G. M. Dawson at its meeting in Montreal last May. The paper dealt with the geological facts and grounds upon which the Quebec group rested and made it a necessary term in the geological sequence of strata in North America, but especially in the Province of Quebec.

The separation of the various formations constituting this natural group based upon faunal as well as on other physical relations, pointed clearly to the existence of such a series of highly fossiliferous sedimentary strata as that which Sir William Logan had recognized and Mr. Billings so clearly demonstrated early in the sixties.

The removal of the so-called Hudson River black graptolitic shales, etc., such as are met at Quebec City, on the island of Orleans, along the Marsouin river, and other places in the Province of Quebec, and at Normans Kiln in New York state, in Penobscot Co., Maine, etc., from the upper-most position in the Ordovician system i.e., immediately above the Utica formation, or just below the base of the Silurian (Upper Silurian) system was absolutely necessary in the light of facts, whether palæontological, stratigraphical or of other physical reasons.

The characteristics of this series of rocks when studied in the field as well as in closer detail, point clearly to its intimate relation and association with the Lévis formation of Sir William Logan's Quebec group. The Lévis formation and the Quebec formation along with the Sillery, form a group of three formations which are capable of being subdivided in many instances into smaller zones and subdivisions, but all of which were deposited under similar conditions at a period forming the lower half of the Cambro-Silurian or Ordovician period in geology. It will thus appear that the rocks constituting the Quebec formation (which term has been used to designate the hitherto so-called Hudson River graptolitic shales, having been adopted by Prof. Walcott and other American geologist,) form part and parcel of the Quebec group of Sir William Logan and fall naturally as a division of that group.

The intimate relations stratigraphical, palæontological and physical which exist between these three terranes are very evident, and the paper goes on to deal with the faunas entombed in each. Extreme care has been taken to base all deduction, whether palæontological or otherwise, on facts, and whether the species of fossils found and noted occur *in situ* or not, in loose bowlders scattered in the fields, or whether they occur in pebbles or in the paste of conglomerates and conglomerate-like bands, also where they occur, and the precise locality and place in the series have been ascertained, so as to leave out possibilities of error as much as possible in a problem, which, like the present one, affords such diversity of relations and complexity of structure.

This paper is in fact a sequel to the author's paper read before the Geological Society of America at Washington last December, and published amongst the Bulletins of that Society last April. (See Bull. Geol. Soc. Am., Vol. 2, p. 4, TF—502, Plate 20.) It will contain a synoptical

list of the faunas entombed in the strata constituting the Quebec group in the Province of Quebec, and reference, etc., points of contact between these and similar series in the Newfoundland section.

On the Lower Cambrian Age of the Stockbridge limestone. By J. E. WOLFF. Bulletin, G. S. A., vol. ii, pp. 331-338, with two figures; March 18, 1891. A detailed description of the structure of the Green mountains and western parallel valleys and ridges in Rutland, Vt., is here given with a map and a section. The rocks dip steeply eastward and comprise, in order from east to west, (1) the Green mountain gneissic schists, with beds of conglomerate; (2) quartzite, proved by Walcott's discoveries to belong to the Olenellus zone of the Lower Cambrian; (3) the limestone of the Rutland valley, in which Dr. A. F. Foerste and Dr. Wolff last year found fossils at numerous localities, including a *Salterella* closely resembling or identical with *S. curvatus* of the Olenellus Cambrian of North Attleboro, Mass.; (4) quartzite, conglomerate, gneiss, and schists, forming Pine hill; (5) the limestone of the Center Rutland valley, in which Dr. Foerste has detected fossils of Lower Silurian age, like those found by Rev. A. Wing in the West Rutland limestone; (6) a belt of schists; (7) the limestone of the West Rutland valley; and (8) the schists of the Taconic range. The stratigraphy includes overturned folds and probably a thrust plain along which the Cambrian is pushed westward to overlie the Lower Silurian limestone.

This paper has an important bearing on the vexed Taconic question, since in verifying the stratigraphy of the lower part of the Taconic as made out by Dr. Emmons, conforming in that respect with results published in the last number of the GEOLOGIST by Mr. Dale, it shows the partial incorrectness of the stratigraphic scheme lately published by Mr. Walcott, and earlier by Prof. Dana.

The Geology of Mount Diablo, California. By H. W. TURNER. With a supplement on *The Chemistry of the Mount Diablo rocks*, by W. H. MELVILLE. Bulletin, G. S. A., vol. ii, pp. 383-414, with a map and three figures; March 30, 1891. Mount Diablo, an isolated peak of the Coast ranges, lying 27 miles east of San Francisco and rising nearly 4,000 feet from the sea level, was selected by Whitney, in the Geological Survey of California, for detailed examination, which resulted in the discovery that the greater part of the metamorphic rocks of these ranges are of Cretaceous age. More recently Mr. G. F. Becker, of the U. S. Geological Survey, has shown that only the Neocomian or basal strata of the Cretaceous series have been highly silicified, serpentinized, and otherwise altered; and the continuation of this investigation by further field work and chemical analyses is described in the present paper. The metamorphism probably took place at the time of the first folding and uplift of the Sierra Nevada, which Becker refers to the close of the Gault epoch. After this date four terranes, namely, the Chico, Tejon, Miocene, and Pliocene, were deposited in succession and conformably with each other upon the Mount Diablo area; and the main upheaval of this mountain occurred, according to Mr. Turner, at the close of the Pliocene. The uplift of the central metamorphic mass was so energetic that part of the strata to the south were thrown into an overturned fold, and in one

locality there is an overthrust fault, with horizontal displacement of about one mile. As to the nature of the disturbances which in late Tertiary time and at its end formed the system of the Coast ranges, this author believes, with Whitney, that they were "sudden and sharp, so that the result may be called a crushing and breaking rather than an uplifting and folding."

Two belts of fossiliferous black shale in the Triassic formation of Connecticut. By W. M. Davis and S. Ward Loper. Bulletin, G. S, A. vol. ii, pp, 415-430, with three figures; April 9, 1891. Professor Davis during tne past nine years has given much study to the Triassic area of the Connecticut valley, and the first part of this memoir gives a summary of his conclusions, as published more fully in earlier papers, concerning the structure of the Triassic formation, with its several trap sheets, in the vicinity of Meriden. Three principal overflows of lava, named by Percival the anterior, main, and posterior trap sheets, are interbedded with the upper half of the conglomerates, sandstones and shales; and besides at least one great intrusive sheet is found, its position being below the overflow and near the base of the formation (Am. Geologist, vol. iv, p. 112). The epoch of deposition was terminated by an upheaval, in which the whole series of aqueous and igneous beds were tilted and faulted, being divided into long narrow blocks, from an eighth of a mile to a mile or more in width, with dislocations of upthrow on the southeast side of the fractures, varying from a few tens of feet up well toward 2,000 feet. Denudation ensued during the Jurassic and Cretaceous periods, reducing this broken country to a surface of moderate relief and low altitude; but about the beginning of the Tertiary era it was again elevated, and the present hills formed by the outcropping edges of the trap sheets are partial measures of the extent of erosion since that time. These interpretations of the structure and history of the area have enabled the authors to discover a considerable number of new localities of the two fossiliferous horizons of black shales which were before known in Durham and Westfield. The extreme points at which the Durham or lower bed has been thus identified are about fifteen miles apart, with ten well proved faults between them; while fossiliferous outcrops probably belonging to the Westfield or upper bed are found in places separated by fifty miles and by twelve or more faults.

The greater part of the search for fossils has been done by Mr. Loper, who describes his methods of work and the localities which have been successfully explored. His provisional list of species comprises eleven fishes and ten plants, with others undetermined; and the search has yielded about 450 specimens of fossils, in addition to the many hundred which had been previously collected in Durham. Five species of fish and five of plants are common to both the lower and upper fossiliferous belts, which are here called respectively anterior and the posterior black shale, from the nearly associated trap sheets.

Pantobiblion. An "international bibliographical review of the world's scientific literature."

This is a very comprehensive and ambitious new journal, at least in the scope which it proposes to cover. It is edited by A. Kersha, C. E.,

and it is published at St. Petersburg, Russia. If it can be carried out on the plan of the first No. which was recently issued, there is no doubt that it will be a valuable publication for librarians, scientists of all kinds, and all students who desire to keep acquainted with the work of their fellows in other countries. But it will require a great outlay of money, and a large corps of sub-editors to abstract the proper condensed notes from the various publications of the world, and it will have to have free access to all scientific publications. This will require the establishment, at once, of a library of large dimensions. The first number contains about 1,200 titles of new publications, 80 critical articles or reviews of leading books, and an index of contents of 270 periodicals, and embraces scientific literature of all countries of the civilized world, in all the principal languages. New York, D. Appleton & Co.

Geology of the environs of Quebec, with map and sections. JULES MARCOU. (From the Proc. Boston Soc. Nat. Hist., Vol. XXIV, pp. 202, 227.)

This is a clear and concise statement of the geological features of the vicinity of Quebec. It treats especially of the falls of Montmorency, Charlebourg, Indian Lorette, Quebec City, Point Levis and La Chaudière's fall. With the exception of a narrow belt of Champlain rocks which is represented running east and west from the vicinity of Montmorency falls to and west from Indian Lorette, all the concerned region is included in the Taconic (upper and middle). The structure of the rocks at the Redoute, at Point Levis, and of the hill at Quebec are represented to be similar, in that there is an *under dip* of the strata, at both points, on each side of the hill, the intervening strata, forming the elevated part of the hills, being supposed to wedge out downward, owing to the sharp folding and the close pressure. The fossils lately found by Mr. Ami and others indicating a more recent age for these strata are believed by Mr. Marcou to be not indicative of their age, being some of them entirely new species, and when not new, entirely explainable on the theory of Barrande "*des colonies*," and strictly of Taconic age. The quartzyte at Montmorency falls he considers of unknown age, though there is no valid reason against considering it of the age of the Granular quartz, of Vermont. Until it can be shown that between the time of the Trenton, which lies horizontal on the quartzyte at Montmorency falls, and the Taconic which is everywhere subject to great upheaval and to the interstratification of igneous rock and to the unconformable overlie of the Trenton, there was an epoch of rock-making like these Quebec rocks, and that later, and before the advent of the Trenton, these strata were upturned to verticality, the general geognosy of the region certainly seems to agree with the views of Mr. Marcou. The rocks that may be said to intervene between the Trenton and the Taconic in the region are the Chazy, Calciferous and the St. Croix, but these, wherever they have been identified, are nearly horizontal and indicate nothing of contemporary volcanoes and later upheaval and crumpling, and within so small an area they could hardly be expected to vary so much. The researches of Mr. Ells, under the Geological Survey of Canada, point to the conclusion that these rocks are divisible between

the Cambrian and the Taconic, i. e. between the second and the first faunas. The Levis strata and the City of Quebec rocks he places together under the term Levis (for which, however, Mr. Ami prefers to retain the name Quebec), and the Sillery strata, underlying the Levis, he would locally designate by the term Sillery. This Sillery consists of two parts, a series of shales and sandstones and a series of quartzytes and limestones, the latter unconformable below the former. This unconformity within the Sillery, which is the Taconic of Emmons, corresponds with a great break which has elsewhere been discovered in the Taconic, and apparently marks the date of outbreak of the eruptive facies of that period. The red shales of the upper Sillery are analogous to the red shales and sandstones of the Georgia of Vermont, and of the upper part of the Nipigon series of the Northwest, and the underlying limestone and quartzyte seem to be on the stratigraphic level of the Winooski marble and Granular quartz of Vermont, and of the Pewabic quartzyte and "cherty limestone" of the Mesabi range in Minnesota. This would make the Sillery the representative of the upper iron-bearing formation of the Northwest, and of the Taconic district of western New England. The intensity of this outbreak, and its wide extent, are shown in the fact that it accompanies this horizon all along the Appalachian chain, through New Jersey, into the Courtland region of New York, the Adirondacks, and thence through the Canadas to the regions of the Great Lakes.

An Expedition to Mt. St. Elias, Alaska. ISRAEL C. RUSSELL. (Nat. Geog. Mag. Vol. III, pp. 53, 204, May 29, 1891.) Eighteen plates, $1.50, Washington.

This very interesting and valuable number of the National Geographic Magazine, which is wholly taken up with this report, contains a very full description of the experiences, and the results, of the expedition of 1890, under the auspices of the National Geographic Society, led by Mr. Russell. The usefulness of modern photography to geology and geography is beautifully illustrated in the numerous handsome plates which are given. The volume is a very valuable addition to the literature concerning Alaska, and adds very much to all former reports on the topography, geology, and especially on the glacial geology of that territory.

Geological Survey of New Jersey. Annual Report for 1890. JOHN C. SMOCK, state geologist, Trenton. 1891. pp. 305, three maps.

This valuable report embraces a summary report by Prof. Smock, a brief report by E. A. Bowser on the condition of the Coast and Geodetic Survey in the state, a report on the geology and other features of the iron mines by Frank L. Nason, including a chapter on the post-Archean age of the white limestones of Sussex Co., and an elaborate report by C. C. Vermeule on the water-supply and water-power of the state. Altogether the document indicates a state of healthy activity for the survey.

We have noticed the high scientific value of the report of Mr. Nason who has brought out some very important facts respecting the white limestones and iron ores of Sussex county. Already this had been foreshadowed by the article of Mr. Nason in the April No. of the AMERICAN

GEOLOGIST (Vol. VII, p. 241), on the *Post-Archean age of the white limestones of Sussex county*. It is true that the views of Dr. E. Emmons since 1846, and of all his school, have made the Taconic strata pass through that part of New Jersey, for it is well known that the geology of northern New Jersey is but a continuation of that of southeastern New York, but the views of Prof. Dana as to the Archean age of these gneisses, and of the accompanying limestones, based as they were on the supposed infallibility of chondrodite as a sign of that age, have prevailed very largely, and these ores have therefore been classed as Archean. The discovery of Olenellus in the quartzyte underlying the limestone effectually removes them from the Archean, and as fatally overthrows the dictum that chondroditic limestones are certainly Archean, since large quantities of that marked mineral are found in them here. It even points to the reverse, and shows that if chondrodite has any value as an indicator of the age of a limestone, it marks the limestone containing it as Taconic. Another important point established is the primordial (Taconic) age of the iron ores, and their close association with that limestone, which, coming from the so-called Archean region in southeastern New York, was carefully traced by Prof. Dana through western Connecticut, northward to Stockbridge, Mass., and to Rutland, Vt., where recently it has been proved to be of the same age by a similar discovery of Taconic fossils by Wolff and Foerste. This bears strongly against the idea that any part of the iron-bearing beds of the region traversed by this limestone are of the age of the Hudson River.

The fossils that have brought about this result, and the chondrodite which have been found in the limestones, have both been determined by associates of Prof. Dana, at New Haven, the former by Dr. C. E. Beecher, and the latter by Prof. S. L. Penfield. These results are no surprise to geologists who have watched the course of geological research with its tendency, relating to the Taconic, during the last six or eight years.

There are, however, two important points in Mr. Nason's report, included apparently in his "conclusions," to which we can not yet subscribe fully. *First*, it does not seem sufficiently proved that the blue limestone is the same in age as the white. It shows some singular contrasts and divergences. If both can be found to be fossiliferous that would settle it. *Second*, it is not sufficiently shown that there is no gneiss (as distinguished from granite) and that all the acidic crystalline rock concerned is eruptive. There is a vast amount of testimony that the limestone is interbedded and conformable with gneiss. It is hard to conceive how a limestone can be placed there, a fossiliferous limestone, and a quartzyte, without some other fragmental rocks to accompany them. If the limestone and the quartzyte are metamorphosed, what is the probable condition of those other fragmentals? Further north this limestone is said to be accompanied by conformable gneiss and mica schists.

The Texas Permian and its Mesozoic Types and Fossils. (Bulletin of the U. S. Geological Survey No. 77, as stated on p. 8.)

In this bulletin is presented a summary of the various kinds of evidence indicating the Permian age of a certain series of the strata in

western [i. e. northern central] Texas, which have been by some geologists referred to the Trias, and by others to the Permian.

It also contains an announcement of the discovery in those strata of certain types of invertebrate fossils which usually are regarded as indicative of their Mesozoic age, commingled with a considerable number of Carboniferous types. This discovery is the first of the kind that has been published concerning North American strata, but it is similar in character to those made by Waagen in India, Gemmellaro in Sicily, and Karpinsky in Russia. A large proportion of the forms are well known Coal-Measure species. All these species are illustrated on accompanying plates, and some of them are described as new.

The paleontological balance which is indicated by this commingling of earlier and later types in the Texan strata is treated as an item of evidence in favor of the Permian age.

The closing portion of the bulletin is devoted to a general discussion of the subject of the existence of the Permian in North America.

Paleontologically this is a most important contribution to knowledge of North American geology and will be of inestimable value to the future student. The historical and stratigraphic discussions together with the generalizations in the concluding chapter do not, however, coincide with numerous observations of more extensive workers in the field. While Hitchcock's and McGee maps—which have never claimed to be anything but compilations—may have represented the area of the Red Bed formation in which the fossils occur as Triassic, numerous geologists of ability, Marcou, Newberry, Ball, and others, have always spoken of the lower division in which they occur as of probable Permian age. Prof. Ball, to whom credit is due for the scientific announcement and determination of the particular localities discussed, first called attention to its vertebrates, invertebrates and plants. (See American Naturalist, June, 1879, Sept. 1880). This naturalist, whom Dr. White seemed to have overlooked, died in the field while exploring the region and published only brief mentions which attracted Prof. Cope's attention to this unique field. The plants, which promise to be of as great interest as the vertebrates and invertebrates, although announced twenty years ago, have not yet attracted the attention of our paleo botanists.

The especial interest of this paper is the fact that it determines paleontologically that of the great American terrane, known as the Red Beds, only the basal portion are of Premian age. These Red Beds, although occupying an area in Oklahoma, Kansas, Texas, New Mexico, Indian Territory, Utah and Arizona, equivalent to at least a twentieth of the area of the United States, have never been systematically studied or published. Numerous writers, Newberry, Marcou, Powell, Shumard, Cragin, Hay and others, have contributed local data, but no one has studied the terrane as a whole. Newberry, Marcou, Walcott, Hill have pointed out the different aspects of the upper and lower beds and expressed opinions as to their diverse ages. Dr. G. G. Shumard, who studied the uppermost Red Beds, argues from their paleontologic evidence that they are Cretaceous,* exactly as Dr. White argues

*See a Partial Report of the Geology of Western Texas, by Prof. G. G. Shumard, Austin, 1886.

from fossils collected at their base that they are Permian. Hill has shown in his Arkansas report the occurrence of typical Red Bed colors and gypum and that the upper limits are of Trinity age. (Uppermost Jurassic or basal Cretaceous). The fact is that the great Red Beds formation began in late Carboniferous times, continued during Permian, Triassic and Jurassic into the lower Cretaceous and should be discussed as a structural unit and not a time unit; the student who will thus treat it has a grand field in American geology.

Tbis *Red Beds Premian* must not be structurally confused with the Permo Carboniferous limestones of Kansas and with the white Permian limestones of the Guadalupe mountains as defined by the brothers Shumard. It is a later and overlying terrane, especially distinguished by complete absence of limestones except one stratum at its very base.

Page 14 gives a section of the strata from eastern Navarro to Swisher county, Texas, including the Cretaceous, Carboniferous and Permian. The *beds* of the Upper Cretaceous Series are treated as distinct formations, to-wit: (1) the Timber Creek formation, (2) the Eagle Ford formation, (3) the Austin formation, (4) the Ripley formation. The reviewer can not agree with this new and inadequate nomenclature in place of the one so well established and in local use in the region, nor can it fill the stratigraphic requirements. These beds are not *formations* but merely *beds* on one great formation, and the term Ripley and Timber Creek have no meaning in the Texas Region; Cope showed in the American Naturalist, 1887, that the latter name when first applied by Hill to the Lower Cross Timber beds had previovsly been applied to a terrane in New Jersey, while Hill has shown that the term "Ripley group" of Hilgard applied to only one horizon in the Glauconitic or Upper division of the Upper Cretaceous series of Texas. Neither does the section include the great division known as the Ponderosa marls lying along the Austin chalk or the Upper or white cliffs chalk so well marked in northeast Texas and Arkansas.

RECENT PUBLICATIONS.

I. *State and Government Reports.*

Reports on the Iron Ore District of East Texas; from 2nd Ann. Rep. Geol. Surv. Texas.

An account of the progress in Geology for the years 1887 and 1888, by W. J. McGee. From the Smithsonian Report for 1888, Washington, 1890.

The Iron Ores of Minnesota, by N. H. and H. V. Winchell. Bull. No. 6 Geol. and Nat. Hist. Surv. of Minn. with map, 26 fig. and 44 plates, 1891.

Report on the Cahaba Coal Field, by Joseph Squire, with App. on the Geology of the Valley Regions Adjacent, by Eugene A. Smith, with map, 7 plates and 31 figures. Geol. Surv. of Alabama.

New General Map of the Anthracite Region, revised to 1890. Geol. Surv. of Pennsylvania.

Mines and Mineral Statistics of Michigan, by C. D. Lawton, Lansing, Mich., 1891.

II. *Proceedings of Scientific Societies.*

Proceedings and Trans. Roy. Soc. of Canada, Vol. VIII, contains: Drift Rocks of Central Ontario, A. P. Coleman; On the density of weak Aqueous Solutious of certain Sulphates, J. G. MacGregor; On a peculiar form of metallic iron found in Huronian quartzyte, on the north shore of St. Joseph island, Lake Huron, Ontario, G. Christian Hoffman; Notes on specimens of nephrite from British Columbia, B. J. Harrington; On the later physiographical geology of the Rocky Mountain region in Canada, with special reference to changes in elevation, and to the history of the Glacial Period, George M. Dawson; On fossil plants from the Similkameen valley and other places in the southern interior of British Columbia, Sir J. Wm. Dawson; Descriptions of some new or previously unrecorded species of fossils from the Devonian rocks of Manitoba, J. F. Whiteaves; Foraminifera and Radiolaria from the Cretaceous of Manitoba, Joseph B. Tyrrell; The evidence of a Nova Scotia Carboniferous conglomerate, E. Gilpin, Jr.; Illustrations of the fauna of the St. John group, G. F. Matthew: Southern invertebrates on the shores of Acadia, W. F. Ganong.

Proceed. of Amer. Forestry Association, at Quebec, Sept. 2-5, 1890, and at Washington, Dec. 30, 1890.

Bul. of the Amer. Geograph. Soc., Vol. XXIII, No. 2, June 30, 1891. Orkneys and Shetland, by Prof. C. S. Smith; Proposed Exploration of North Greenland, by R. E. Peary; Journeys on Inland Ice.

III. *Papers in Scientific Journals.*

The Ottawa Naturalist, Vol. V, No. 3, contains: On the Nickel and Copper Deposits of Sudbury, Ont., by A. E. Barlow.

The School of Mines Quarterly, April, 1891, contains: On the Genesis of Ore-Deposits, by W. H. von Streeruwitz; An Assay Furnace, by Herbert Wood; Manufacture of Slag Bricks in Montana, by T. Egleston; The Treatment of Copper Slates at Mansfeldt, by T. Egleston (concluded); A Brief Review of the Literature on Ore-Deposits, by J. F. Kemp (concluded).

The National Geographic Magazine, May, 1891, contains: An Expedition to Mount St. Elias, Alaska, by Israel C. Russel.

The American Naturalist, June, 1891, contains: A Recent Lava-Flow in New Mexico, by Ralph S. Tarr.

The Journal of the Cincinnati Society of Natural History, April, 1891.

Zoe, April, 1891, contains: A Miocene Shell in the Living State, by J. J. Rivers; Use of Broken Pottery Among Indians, by Edward Palmer.

Am. Jour. Sci., July No., contains: Newtonite and Rectorite, two new minerals of the Kaolinite group, R. N. Brackett and J. F. Williams; New analyses of astrophyllite tscheffkinite, L. G. Eakins; Minerals in hollow spherules of rhyolite, from Glade creek, Wyoming, J. P. Iddings and S. L. Penfield; Bernardinite: is it a mineral or a fungus?

J. S. Brown; Development of Bilobites, Charles E. Beecher; Gmelinite from Nova Scotia, L. V. Pirsson; Analyses of kamacite, tænite and plessite from the Welland meteoric iron, John M. Davison.

Geol. Mag., July, 1891, contains: Note on a nearly perfect skeleton of *Ichthyosaurus tenuirostris*, R. Lydekker; The perched rocks near Austwick, T. M. Reade; The lower Cretaceous series of the vale of Vardour, A. J. Jukes-Browne; The recent elevation of the Himalayas, H. H. Howorth; On dynomic metamorphism, A. Irving; Rutile in Fireclays, W. M. Hutchings; On the British Earthquakes of 1889, C. Davison.

IV. *Excerpts and Individual Publications.*

Discovery of a Paleolithic Implement at Newcomerstown, Ohio, by W. C. Mills and G. Frederick Wright. Tract No. 75 of West. Reserve Hist. Soc., Cleveland.

Museums and Their Purposes. A Lecture before the St. Paul Acad of Sciences, by N. H. Winchell.

On the Unconformities between the Rock-systems underlying the Cambrian Quartzite in Shropshire, by Charles Callaway. From Quart. Jour. Geol. Soc., May, 1891.

Preliminary Paper on Artesian Wells in Iowa, by R. Ellsworth Call. From Monthly Rev. Ia. Weather and Crop Serv., April, 1891.

On the Young of Bacellites compressus *Say*, A. P. Brown. From Proceed. Acad. Nat. Sci. Phil.

On Some Causes which may have Influenced the Spread of the Cambrian Faunas, by G. F. Matthew. From Can. Rec. Sci., Jan., 1891.

The Flood Plains of Rivers, by W. J. McGee. From the Forum.

Encroachments of the Sea, by W. J. McGee. From the Forum.

Contributions to Canadian Palæontology. Vol. I, Part III. The Fossils of the Devonian Rocks of the Mackenzie River Basin, by J. F. Whiteaves. Geol. and Nat. Hist. Surv. Can.

V. *Foreign Publications.*

Chillagoe and Koorboora Mining Districts, by R. L. Jack, Townsville, Queensland.

Stavanger Museum. Aarsberetning for 1890.

Transactions of the Geological Society of Glasgow, Vol. IX, Part I, contains: On the fructification and internal structure of Carboniferous Ferns in their Relation to those of Existing Genera, with Special Reference to British Palæozoic Species. By Robert Kidston, F. R. S. E., F. G. S. With four Plates (Nos. I to IV).

Literature specially referring to the Fructification and Internal Structure of Carboniferous Ferns.

On the Internal Structure of the Carboniferous Corals forming the Genus *Chætetes* of Fischer. By John Young, F. G. S., *V. P.*

Notes upon a Cutting in the New Kilbirnie Branch of the Lanarkshire and Ayrshire Railway, on the Farm of Gurdy, Beith. By Robert Craig, Langside, Beith, *Corresponding Member.*

List of Fossils in Gurdy Cutting.

On New Localities for Zeolites. By Professor M. Forster Heddle, M. D., F. R. S. E. With two Diagrams.

On some *Estheriæ* and *Estheria*-like Shells from the Carboniferous Shales of Western Scotland. By Prof. T. Rupert Jones, F. R. S., F. G. S., *Honorary Member*. With a Plate (No. V).

On a Peculiar Structure—Spines within Spines—in Carboniferous Species of the Productidæ. By John Young, F. G. S., *V. P.*

The Geology of the Lugton Valley. By James S. M'Lennan.

Phenomena of the Glacial Epoch: II. The "Great Submergence." By Dugald Bell, *V. P.*

The Surface Geology of Paisley. By Matthew Blair.

The Great Ice Age in the Garnock Valley. By John Smith, Kilwinning. With four Plates (Nos. VI to IX).

Notes on Gairloch, Ross-shire. By James White.

Note on the Occurrence of Footprints in the Calciferous Sandstone between West Kilbride and Fairlie. By John Smith, Kilwinning. With a Drawing to Scale.

Notes on the Visit of the Geological Society to Bowling on 23rd March, 1889. By W. J. Millar, C. E. With a Drawing.

Journal of a Bore put down for Water at Thornliebank, Renfrewshire. With Notes on the Strata, by J. B. Murdoch, *Hon. Secretary*. [Abstract only].

On Mammalian Remains from Cresswell Crag Bone Caves. By Professor John Young, F. G. S., *Hon. Member*.

On things New and Old from the Ancient Lake of Cowdenglen, Renfrewshire. By James Bennie, Geological Survey of Scotland.

Eclogæ Geologicæ Helvetiæ, Vol. II., No. 3, contains: Les Hautes-Alpes vaudoises de *E. Renevier*, par M. Aug. Jaccard; Envahissement de la mer éocénique aux Diablerets, par E. Renevier; Origine et âge du gypse et de la cornieule des Alpes vaudoises, par E. Renevier; Transgressivité inverse, par E. Renevier; Chaine du Reculet-Vuache, par Hans Schardt.

Zeits, der Gesell. für Erd. zu Berlin, Band XXVI, No. 2, 1891, Georg Kollm, contains: Das südlichste Brasilien, von Dr. Alfred Hettner; Die flachentreue transversale Kegel-Projektion für die Karte von Afrika, von Dr. Alois Bludau; Aus den Briefen Peter Martyr Anghiera's. Notizen aus der Geschichte du grossen Landerentdeckungen, von Eugen Geleich.

Bericht du meteorolog. Commission des naturfor. Vereines in Brunn., 1890.

Verhand. d. Gesell. für Erd. zu Berlin. Band XVIII, No. 4, Georg Kollm.

Mittheil. d. Ver. für Erd. zu Leipzig, 1890.

Verhand. d. naturfor. Ver. in Brunn. Band XXVIII, 1889.

Geol. Asie et Amérique, par Emm. de Margerie, Paris, 189 0.

Twenty-fifth Ann. Rep. of the Col. Museum and Laboratory, by Sir James Hector. New Zealand, 1891.

A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales. Part I. By R. Etheridge, Sydney, 1891.

VI. *Museums and Scientific Laboratories.*

Report of the Dep. of Nat. Hist. By Oliver Marcy. Northwestern Univ. 1891.

Bul. Sci. Labor. of Denison Univ., Vol. VI, Part I. By W. G. Tight.

Nebraska Flowering Plants, by G. D. Swezey. Doane College, May, 1891.

Twenty-third and Twenty-fourth Ann. Reps. of Trustees of Peabody Mus. of Amer. Arch. and Ethnol. Cambridge, 1891.

Rep. of the Sci. Exped. into South. Maryland. Johns Hopkins Univ. Cir. Vol. X, No. 89.

CORRESPONDENCE.

Area and Duration of Lake Agassiz. Your July number contains a valuable article by J. B. Tyrrell, in which he criticizes the estimate of the area of lake Agassiz, about 110,000 square miles, or more than the conbined areas of the great Laurentian lakes, as given in my recent report published by the Canadian Geological Survey. In reply I wish to explain that I have not attributed so great extent to lake Agassiz at any one stage of its existence, and to notice briefly how the beaches and terminal moraines indicate that this lake during both its earlier and later stages covered the greater part, probably three-fourths, of this area.

The chief argument for this is the observed extent of the higher and earlier Herman and Norcross beaches, which have been mapped from near Red lake, Minnesota, southward to lake Traverse and thence northward through North Dakota to Riding and Duck mountains in Manitoba, a distance of about 700 miles (Am. Geologist, vol. vii, pp. 194, 222). Delta sand deposits. brought into lake Agassiz by the Saskatchewan and referable to the Norcross and lower stages, reach from near Prince Albert, on the North Saskatchewan about forty miles west of the forks of the North and South branches, through a distance of more than a hundred miles eastward to the head of the Seepanock channel and the 103d meridian (Canadian Pacific Railway Report, 1880, pp. 14, 19). The descent of the river in this distance is approximately from 1,250 or 1,300 to 950 feet; and the elevation of the west part of the delta is probably about 1,350 feet above the sea. As early as the time of the Norcross beaches, therefore, the recession of the ice-sheet had permitted the lake to extend along the whole front of the Manitoba escarpment, to the latitude of the north end of lake Winnipeg. The length of the Agassiz at that time was 550 miles or more, and I believe that its average width was not less than 150 miles, reaching east to the moraine which Mr. Tyrrell describes as forming the eastern shores and islands of lake Winnipeg, with a hight of 100 feet on Black island. This moraine would then have been deposited in water 600 to 700 feet deep, bordering the ice-margin ; its knolly and irregular accumulations of drift would not have been subjected to the levelling action of the lake waves until the farther melting of the ice opened avenues of outflow to the Hudson bay and reduced the glacial lake nearly to the level of lake Winnipeg ; and the latest change of the northward outlets may have lowered the water surface so rapidly and to such vertical amount that it left no distinct marks of erosion or shore lines on the upper portion of the moraine.

Before the successive northward outlets began to drain lake Agassiz below its channel of southward discharge at lakes Traverse and Big Stone, the border of the ice-sheet had been gradually melted back from lake Winnipeg to Hudson bay, and its thick central part which occupied the basin of Hudson and James bays had so far disappeared as to admit the sea there. At a time of halt or reädvance, interrupting this recession, another terminal moraine appears to have been accumulated, crossing the Churchill and Nelson rivers, as observed by Dr. Bell (Bulletin, G. S. A., vol. i, pp. 303, 306). If this belonged to the time of the Campbell or McCauleyville beaches, as seems most probable, the extent of the lake during these later stages of southward outflow was even greater than I have supposed it to be at the time of the Herman and Norcross beaches, and the area occupied by lake Agassiz in its numerous stages much exceeded that of my map and estimate.

Though lake Agassiz attained vast areal extent, its duration or extent in time was short, as is shown by the small volume of its beach deposits and lacustrine sediments in comparison with lakes Bonneville and Lahontan and with the amount of post-glacial erosion and deposition on the shores of the great lakes tributary to the St. Lawrence and Nelson rivers. The geologic suddenness of the final melting of the ice-sheet, proved by the brevity of existence of its attendant glacial lakes, presents scarcely less difficulty for explanation of its causes and climatic conditions, than the earlier changes from mild or warm preglacial and inglacial conditions to prolonged cold and ice-accumulation.

Somerville, Mass., July 7, 1891. WARREN UPHAM.

TO THE MEMBERS AND FRIENDS OF THE CORRESPONDING GEOLOGICAL CHAPTER OF THE AGGASIZ ASSOCIATION: This brief report, covering the first year of the existence of the C. G. C. A. A. is published for the benefit of its members, and also for the information of others who are interested in geological pursuits and to whom the workings of the Chapter are unknown.

The Chapter was organized in February, 1890, with a charter membership of sixteen. The constitution is modelled after that of the Gray Memorial Botanical Chapter of the A. A. It is our primary aim to organize lovers of natural science throughout the land who are actively interested in geology or its kindred branches, and to establish a stated means of communication whereby each may know what all the others are doing. By this means the student or amateur geologist of New England comes into correspondence with the workers in the South and West, and acquires a more accurate knowledge of these remote regions than would otherwise be possible. All the machinery of the organization is subservient to this central idea,—the mutual encouragement and help of workers in different sections of the country. Each member is expected to contribute a report every three months "giving the result of his studies and personal researches in geology, mineralogy, or paleontology during the previous quarter." These reports are then circulated throughout the Chapter, affording each member the opportunity to read, comment, and criticise. The experience of a year is abundant

evidence that this plan is a most successful means of developing talent and enthusiasm in geological work.

During the year our numbers have increased from sixteen active members to thirty-two active and three honorary members. We have eleven active members in New York state, seven in Massachusetts, two in Connecticut, two in Illinois, and one each in Rhode Island, Pennsylvania, New Jersey, Maryland, Georgia, Ohio, Iowa, Minnesota, California, and Nova Scotia.

The reports are uniformly excellent, giving evidence usually of a strong interest in geological work, and often exhibiting much labor and skill on the part of the writer. Over half of the reports are illustrated with drawings or photographs, which always add greatly to the value of scientific papers. The range of subjects presented is very wide, as would naturally be expected from the variety of regions represented in the Chapter. There is no space here to enumerate even a few of the titles of reports, but we may say, without any risk of exaggeration, that the fruit of our year's work contains material which is valuable not only to the amateur but to the professional geologist as well. Within the year eighty-three reports were received as follows: nineteen in May, twenty-two in August, twenty-one in November, and twenty-one in February, 1891. It will be seen that the increase in number of reports has not kept pace with the increasing membership of the Chapter.

Our plan of work cannot fail to recommend itself to those who are practicing the truly scientific method of geological study; and it is to such students that we extend a hearty invitation to join us. A few more members of the right sort would greatly enhance the efficiency of the Chapter.

Our past experience has suggested a few improvements in our *modus operandi* which are being vigorously discussed among the members. This is not the proper place for a presentation of such matters; the active interest shown by all in the improvement of the Chapter is a good omen and guaranty of greater success in the year to come than in the year just past. The following are the officers for 1891:

President, FREDERICK A. VOGT, 844 Genessee St., Buffalo, N. Y.

General Secretary, GEORGE F. PERRY, Melrose, Mass.

Treasurer, MISS ISABELLA S. DEANE, 45 Park St,, Buffalo, N. Y.

Executive Council, AMADEUS W. GRABAU, Soc. Nat. Hist. Boston, Massachusetts.

Executive Council, FRANKLIN W. BARROWS, High School, Buffalo, N.Y.

All who desire to join the Chapter will please apply to the General Secretary. Very truly,

Buffalo, N. Y., May 20, 1891. FRANKLIN W. BARROWS,
Retiring President.

ORANGE SAND, LAGRANGE AND APPOMATTOX.—The study lately bestowed upon the formations of the southwestern states in connection with those of the North, and especially those of the Atlantic slope by McGee, seems to render a revision and re-definition of the above names desirable. The first two, Orange sand and Lagrange, were first applied in 1856, by Safford, to a series of beds in west Tennessee that bear a very

close resemblence in general aspect; and in the mere reconnoissance then made by Safford of the region, were by him presumed to be of identical age. In a subsequent report (1869) Safford recognized the fact that a portion of the beds included by him in the above designation belonged to the Cretaceous; and he accordingly defines the "Orange Sand or Lagrange group" as being of Tertiary (probably Eocene) age.

Meanwhile I had, in 1856, examined the portion of Mississippi adjacent to the Tennessee line, and in subsequent years up to 1860 the remainder of the state. I had found what I presumed to be Safford's Orange sand more widely developed in Mississippi then even in Tennessee, and found it overlying the latest recognized Tertiary beds—the Grand Gulf rocks. Accordingly I adopted Safford's name in my Mississippi report of 1860, in which the features of the formation are described in considerable detail; and for reasons there given the "Orange sand" is assigned to the early Quaternary.

The intervention of the war prevented any early conference between Safford and myself on the subject; and it was only in 1869 that I learned that Safford assigned his "Orange sand" and "Lagrange," as a unit, to the Eocene age.

During our subsequent correspondence it was developed that lignitiferous beds of unquestionably Eocene age, exposed not far from Lagrange, Tenn., were included by Safford within his group. I therefore suggested to him that the latter name should be retained for the yellow and gray lignitiferous sands of the Eocene that immediately overlie the "Flatwoods" or "Porter's Creek" beds, which themselves overlie directly, and almost conformably, the uppermost Cretaceous. The name of "Orange sand," on the other hand, it was agreed should designate the higher series, to which it is peculiarly appropriate. To this agreement we have since adhered, and have therein been followed by other western geologists.

As stated in my Mississippi report of 1860, I had concluded from the descriptions of Tuomey and others, that the Orange sand extended with more or less similarity of character at least to South Carolina, and probably along the Atlantic coast plain as far north as Washington.

The excellent work carried out for some years past by McGee, along the coastal plain of the Atlantic slope, while restricting somewhat the supposed northward extension of the formation, has shed much new light upon its general relations and regional modifications; and while the identity of the whole is unquestionable and hence the prior designation (Orange sand) should stand in place of the name Appomattox applied by McGee to the Atlantic portion of the formation, yet the deviation of the former name from the accepted rule of forming such names from type localities, as well as a certain degree of confusion that has occurred in its actual use, seems to render a change advisable.

At a late conference on the whole subject, participated in by Messrs. McGee, Joseph De Conte, Loughridge and myself, it was suggested that in view of the various objections to all the later names, that of "Lafayette," which the formation had borne for several years in my early field notes (from the type localities in Lafayette county, Miss., where I first

discriminated it from the Eocene sands), might appropriately be adopted, with the assent of Safford, as one of the parties to the former agreement. This having been secured, it would seem advisable that all unite upon the use, hereafter, of "Lafayette" as the equivalent of the *Orange sand* (as understood by Safford and myself) of the southwest, and of the *Appomattox* as defined by McGee for the Atlantic and southeastern states. Whatever differences of opinion may exist in regard to the genesis of the formation, or the assignment of particular local phases, will be more readily discussed and reconciled when a single name only is employed by all. E. W. HILGARD.

Berkeley, Cal., June 15, 1891.

The above paper was sent to me previous to publication for examination, and, if acceptable, for my approval. Prof. Hilgard has given the correct history of the names "Orange sand" and "Lagrange," and, in the prospect of harmonizing views all around, thereby facilitating the study of the beds concerned, I heartily concur in the conclusion reached by him in conference with the gentlemen mentioned above. It is pleasant to know that, in important points, a satisfactory understanding now exists. JAS. M. SAFFORD.

Nashville, Tenn., June 22, 1891.

Rev of Lit

PERSONAL AND SCIENTIFIC NEWS.

MR. FRANK L. NASON, LATE ASSISTANT GEOLOGIST of the New Jersey Geological Survey, has been appointed to the position of assistant geologist on the Geological Survey of Missouri, and will be in charge of the examination of the iron ores of the state. Other assignments for the summer work of the latter survey are as follows: Prof. Erasmus Haworth has resumed work on the crystalline rocks and will also collect material for the preparation of a report on the mineralogy and petrography of the state. Prof. C. H. Gordon has similarly resumed work in the coal fields, and most of his time will be given to the detailed study and mapping of the coal beds of Macon county. Prof. J. E. Todd, of Tabor, Ia., has been engaged to take up the study of the quaternary deposits of the state and to prepare a report thereon.

PROF. MARK W. HARRINGTON, professor of astronomy and director of the Detroit observatory at Ann Arbor, Mich., was appointed by the secretary of agriculture to have charge of the "Weather Bureau" at Washington, lately transferred from the War Department to the Agricultural Department, and assumed charge July 1st.

THE OGDEN SCIENTIFIC SCHOOL is to be a department of Chicago University. It is based on a gift by Wm. B. Ogden, first mayor of Chicago, lately decided by the executors of the Ogden estate. The conditions attached by the executors to the gift—

which will amount to from three hundred thousand to half a million dollars—are, that the school shall be a separate department of the university, and bear the name of the Ogden Scientific School, its purpose being to furnish graduate students with the best facilities possible for scientific investigation by courses of lectures and laboratory practice. The income of the money appropriated is to be devoted to and used for the payment of salaries and fellowships, and the maintenance of laboratories in physics, chemistry, biology, geology and astronomy, with the subdivisions of these departments. A large share of the time of the professors in the school is to be given to original investigation, and encouragement of various kinds is to be furnished them to publish the results of their investigations, a portion of the funds being set apart for the purpose of such publication. Some portion of the income is to be set apart for the purchase of books to be placed in the special departmental and laboratory libraries of the proposed school.

PROF. P. MARTIN DUNCAN, a well known English geologist, especially in the study of corals, died in May last. As was the case with many others who have become eminent in geology, he began life as a physician, practicing medicine for many years. His first venture in science was in Botany; (Observations on the Pollen-tube, 1856). It was no part of his plan to seclude himself from the active duties of life while engaged in the study of science. He was at the same time mayor of Colchester and curator of the local museum in that town which still shows the evidence of a management far ahead of the time when it was arranged.

Later on Dr. Duncan removed to London, became professor of Geology at King's College and Cooper's Hill, (the East India College,) secretary and vice-president of the Geological Society, and in 1879 president of the geological section of the British Association. In 1881 he received the highest honor in the gift of the Geological Society, the Wollaston Medal, and at different times served on the Council of the Royal Society and presided over the meetings of the Microscopical Society.

Prof. Duncan's chief papers are his "Fossil Corals," the "Physical Geography of Europe during the Mesozoic and Cænozoic eras elucidated by their Coral Faunas," his "Revision of the Madreporaria" and of the "Great Groups of the Echinoidea," with some later ones on "Protozoa and Sponges."

NOTICE.

THE "GEOLOGICAL SWINDLER" AGAIN ABROAD. Readers of the GEOLOGIST will recall several references in the early numbers, Vol. I (1888), to an adept thief who had for several years practiced upon the geologists and other scientists of America with a good degree of success. This fellow was apprehended and served six months' imprisonment in the Elkhorn jail, in Wisconsin, but on release resumed his nefarious tricks. In January, 1888, he stole some microscopic objectives from the University of Cincinnati, and under the instigation of Prof. Chas. H. Gilbert, the police of the city were put upon his trail. After a pursuit of some weeks, tracing him in Indiana, Kentucky, and Ten-

nessee, he was apprehended at Nashville, and on trial was convicted and sentenced for five years for grand larceny, to the State penitentiary at Columbus, O. He pleaded guilty and admitted that he was the "swindling geologist" of numerous aliases.

In confinement he made a good record for himself and was put in charge of the night-school. He would have been released, on account of good behavior, at the expiration of three years and nine months under the rules of the Ohio penitentiary, in the fall of 1891, but under special protestations of reform he was given a degree of freedom at Columbus, which allowed of his release finally "on parole" for the remainder of the term that he had to serve. He remained for a time

quietly at Columbus, as reporter for the Columbus *Sunday World*. Suddenly he appeared at Saginaw, Michigan, in violation of his parole, where he attached himself to the High school principal and addressed the pupils of the High school, claiming to have been a professor in Vassar College, Poughkeepsie, N. Y., and then connected with Smith College, but preferring his present occupation of dealing in fossils, as more remunerative. He sold the High school ten dollars worth of fossils. He said he was a Russian, descended from an eminent Russian geologist, and acquainted with the most distinguished geologists of our country—(his usual story, the latter part, alas, too true!), also that he is the brother of the celebrated nihilist martyr Vera Sussulich, that he had fought in the Franco-Prussian war, and had been made a captain, etc., etc. Thence he went to Lansing, Mich., and the speeches he made there were reported in the *Detroit Tribune* under the title—"A man with a history." At Lansing, he claimed to be a mining engineer, and betook himself to the Agricultural College, where he "named the fossils" in the collection of that institution.

On making inquiry as to the identity of this man with the "O. L. Syrski," who had been a short time before released on parole, it was learned that, "in the language of the streets, Syrski has jumped his parole, beaten his boarding-house, and employer, and skipped," with the incompleted sentence still hanging over his head.

He is now again launched upon the community, to continue to be a scourge to scientists and amateurs. In addition to his standard way of representing himself as a geologist (or other scientist more rarely), as a Russian, often as deaf and dumb, and always making memoranda on little squares of colored writing-paper which he carries in very small vest-pocket blocks, and taking occasion to steal valuable books, instruments, and fossils from his hosts, he now has adopted also the method of corresponding with scientists, especially geologists, soliciting exchanges, which of course he conducts dishonestly.

He is thus described at Saginaw; a man of medium hight, of light complexion, with a light colored moustache, blue or grey eyes of great keenness and rather watery, and a firm jaw, giving decision to his conversation. His language is fluent, and free from any foreign accent or peculiarity. He has lost one or two front lower teeth, and looks to be 35 or 40 years old. The attached half-tone reproduction of his portrait is from a photograph taken by the Cincinnati police at the time of his last trial and incarceration. The negative is held by Vail Brothers, photographers, 254 Main street, Poughkeepsie, N. Y., and their price for a single copy is 25 cents. It is a very accurate portrait of him as he appeared three years ago, as many who have suffered from his thefts can testify, except that he is a little more rough in his personal appearance, in the portrait, than usual.

Short notices of his career are given in *The Naturalist's Leisure Hour* (A. E. Foote's), March, 1884 (written by F. V. Hayden), in *Science*, Jan. 14, 1887, June 17, '87, and in the AMERICAN GEOLOGIST, January, February, and April, 1888, and February, 1889. He has appeared under the following aliases: "Gratacap," "Capt. C. E. Dutton, U. S. A.," "Prof. H. S. Williams," "Ellis," "Ellison," "Reitz M.

Vasiliez," "Vasile," "Vasilief," "Robt. Verrall" or "Varrall," "O. L. Syrski," O. L. Sussulich," "Leo Lesquereaux, Jr." (son of the late eminent paleobotanist), "W. R. Taggard," "Prof. Cameron," "Prof. Leveille," and "E. O. Strong."

No one has yet been found who was a classmate to the swindler, nor has any knowledge been obtained as to the institution where he gained his excellent higher education. He himself declares that he is a graduate of the University of Kief in Russia, but no inquiry seems to have been made into the truth or falsity of the statement. He has shown a familiarity with the Sclavonic languages by conversing freely with Poles and Hungarians in the quarries at Rondont, N. Y., in their own tongues.

We have no vindictive feelings against the man at all, but we believe that we can do no better service to scientists in America than by putting them on their guard against strangers without good credentials, and arming them against "O. L. Syrski," by giving this information.

According to latest information, a one-inch Zeiss microscopic objective, which was on his person when captured in Tennessee, is still in the hands of the chief of police, Cincinnati, unclaimed.

In August, 1887, he procured from Rev. Arthur H. Flack, president of the Claverack College, Claverack, N. Y., a loan of $15 on a spectroscope which he left on his hands "until he should return the loan." Of course the "loan" was never returned, and the stolen spectroscope still awaits its owner at Claverack College.

AMERICAN GEOLOGIST.

May 15, 1891.

Walker Prizes in Natural History.

The Boston Society of Natural History, offers a first prize of from $60 to $100 and a second prize of a sum not exceeding $50, for the best memoirs, in English, on one of the following subjects:

1. An original investigation into any of the problems connected with the geology of the last ice epoch in New England; any of the glacial features, as for instance the distribution and history of morainal deposits and eskers, or of sand plains may be selected.
2. An original investigation into the recent changes of level of the whole or of a part of the shore line of the eastern United States. This inquiry must include observations on and discussions of the phenomena exhibited by elevated sea margins and submerged forests.
3. A study of any river valley in New England, containing an area of not less than one hundred square miles; the inquiry to include the preglacial history of the stream, the changes effected in the basin by the last ice epoch, the relation of the valley to the neighboring basins, and to changes of level of the sea.

Each memoir must be accompanied by a sealed envelope enclosing the author's name and superscribed by a motto corresponding to one borne by the manuscript, and must be handed to the Secretary on or before April 1st, 1892.

Prizes will not be awarded unless the memoirs are deemed of adequate merit.

For further particulars apply to

SAMUEL DEXTER,
Secretary.

Boston, July 1st, 1891.

THE

AMERICAN GEOLOGIST

VOL. VIII. SEPTEMBER, 1891. No. 3.

PRELIMINARY NOTES ON THE TOPOGRAPHY AND GEOLOGY OF NORTHERN MEXICO AND SOUTHWEST TEXAS, AND NEW MEXICO.

By ROB'T T. HILL, Austin, Texas.

The topographic and geologic features of northern Mexico, and the Trans-Pecos region of Texas and New Mexico have been for several years a subject of profound interest to the writer, who, notwithstanding much study, involving thousands of miles of travel, still feels that he can contribute only a few data concerning this vast region, and that the main facts and details of its structure are still unraveled, especially those relating to orographic and igneous geology, and he presents the accompanying description of a small, but typical portion of the area, with the hope that it may be of some assistance to those who are more competent to discuss as a whole the grander orographic features of our continent.

I have previously shown the salient topographic features of the region to consist of:

1. A series of present and ancient coast plains, consisting of strata of Trinity and later age, which covers the eastern half of the state, and collectively form what I will call the coastward incline: This embraces the coast prairies, the Washington prairies, the Eo-Lignitic or Forest region, the black prairie, the Grand prairie, and the two Cross-Timbers. The Llano Estacado in some respects may be classified generally with this region, but for the present, I prefer to treat it separately.

2. The central denuded region, including the great rock sheet of the Paleozoic and early Mesozoic (Red beds) mostly dipping westward, which lie unconformably beneath the group of the coastward incline,

and are exposed either by the removal of the latter through erosion, or being upturned in the two great mountain systems, which limit the region—the Ouachita on the north, and the basin ranges of the Trans-Pecos region and northern Mexico on the west.

3. The above mentioned mountain systems, the first of which the Ouachita system of Arkansas and Indian Territory is older than the plains of the coastal system, and against which they were laid down; and second the Basin mountains which are composed of the uplifted, folded and crumpled southward edges of the earlier of these plains; *i. e.* those founded on rocks of Cretaceous age.

4. Plains of later age than the mountain foldings which were laid down against these newer mountains, and these include the Llano Estacado, and the later formations of the coastal series; and lacustral basins which were laid down between the mountains and in valleys of the plains like the dry lake beds of the latter region.

Many of these features have been described in previous papers, especially those of the eastern half of the Texas region, and in the present paper, I wish to contribute a few facts concerning the Texas-Mexican extension of the Basin region.

Among the most conspicuous of the basins are the lakes Lahonton and Bonneville, numerous unnamed basins in Arizona and in New Mexico; the Mesilla valley, the Franklin-Hueco valley, and El Jornado del Muerto in New Mexico; the valley of the Salt Lakes, the Eagle Flats, and the Toyah-Pecos basin in Texas; and the basin of Presidio Del Norte, plains of Chihuahua, El Bolion de Mapimi; the plains of Lago Aqua Verde, Baroteran Barreal del Junco, Valle Hundido, Valle Labago, Cayote and numerous others.

It should be borne in mind that these plains cover numerous areas, and occupy most of the region, the mountains being far secondary to them in extent and areal importance.

GEOGRAPHIC EXTENT OF THE BASIN REGION.

The topography of the whole of the United States, and northern Mexico, south of the 33° of latitude between the Sierras of California, and the Pecos-Lower Rio Grande, may be defined as a series of vast plains or ancient base-levels studded at remote intervals by mountain blocks sometimes isolated, sometimes in groups or chains. These mountains belong to the style defined by Russell as composed of stratified sedimentary beds which have been broken by profound fractures, and upheaved as great mountain blocks. Surrounding these mountain blocks (and composed

of their debris) and extending like a smooth floor from one to the other are the plains or basins.

There is also much igneous material, but this is a secondary feature, to be mentioned later, and most cases is in the beds of almost recent lakes, above which the mountains but lately (in geologic times) projected as islands. This is the true basin structure so ably described in fractional portions of its extent in Utah and Nevada, by Gilbert, Dutton, Russell, Powell and McGee. In central New Mexico the true Rocky Mountain system ends abruptly against this region, just south of Santa Fe. All mountains north of that point are in the basin region.

The western escarpment of the Llano Estacado and the Pecos river and its continued course in the Rio Grande form approximately the eastern border of the basin region in Texas and New Mexico, while its southern border extends southward through Comanche and eastern Chihuahua in Mexico to the state of Durango.

The principal mountain blocks of this region are the following: In southeastern New Mexico, the Sierra Oscura, the San Andreas, the Juccarillo, Sierra Cabella, Sierra Florida, Sierra de la Hacheta and many unnamed blocks; in Trans-Pecos, Texas, the Orgim Franklin chain, the hueras, the Van Horne, Carrisos and the Las Chisos, Davis mountains, the Chenatis: in northern part of Mexico, the Juarez mountains (near city of Juarez), Sierra del Carmen, Sierra San Vincente, Sierra del Burro, Las Arboles, Las Cruces, Sierra Encantado, Sierra Carrizalyo, Sierra del Santa Rosa, Sierra de Guajes, Sierra Lampazos and many others; the eastern continnation of the region into Mexico.

Intimately and closely associated with these basins, is the westward embayment of the Rio Grande from the coast. This embayment is marked by the southern escarpment of the Edwards division of the Grand Prairie, on the north from San Antonio to Del Rio, and by the Santa Rosa and allied mountains in Coahuila, and is a great topographic depression, up which all the late Cretaceous and Quaternary formations deflect. It is covered more or less to the coast by a detrital deposit of an age probably related to the entirely enclosed basins. The northern (Texan) boundary of this basin is a fault wall—the great Austin-New Braunfels fault of my previous papers.

The southern boundary, in Mexico, is composed of typical

basin mountains occurring in isolated blocks, a type of which will now be described in the Santa Rosa mountains.

These mountains lie south of the Rio Sabinas and west of the Mexican International railway, and rise about 3,000 feet above the plain. They are composed entirely of blue Cretaceous limestone of the Comanche series, here metamorphosed into the firm aspect of the Silurian limestones.

The Sierra de Santa Rosa are among the first true mountains, *i. e.* mountains produced by dislocated or folded stratification, met in northern Mexico. They are the eastern flank of the outliers of the great basin group or system which extends southwestward through the Trans-Pecos region of New Mexico and Texas into northern Mexico, and are the beginning of the great mineral district of the latter region. These mountains rise in beautiful profile above the plain which surrounds them and extends north of them to the Rio Grande, and at a glance they mark the beginning of an entirely distinct geographic and geologic region from the Atlantic coastal region.

Northeastward of these mountains towards Laredo and Eagle Pass extends the plain or basin, which I have described as the Rio Grande embayment which, carved by erosion into valleys and small hills, is a unique geographic feature constituting the drainage basins of the Rio Sabinas and Rio Grande and sometimes called the San Felipe Coal Basin.

1. The Mountains. The Sierra Santa Rosa is an interesting piece of mountain architecture, consisting of an elongated mass or block of hard rock structure surrounded on every side by level plains. They extend northwest for fifty miles west of Baroteran. The mountain is about ten miles wide upon an average, and the main axis or ridge is unbroken by passes. Geographically this mountain always presents three persistent and interesting longitudinal divisions. (a) The Sierra Grande or main mountain constituting the main central axial mass or backbone of the range standing about 1,500 feet above the plain of the basin. (b) The Sierra Chiquita or hog backs—a row of sharp angular mountains, which lie parallel to and on the north side of the Sierra proper. There are some fifteen of these separated from each other by narrow canons of erosion, and from the Sierra Grande by an irregular grand chasm. These Chiquitas are about 500 feet above the plain, and are the most important of the geographic divisions, economically,

in that they and their foot hills (the lomitos) contain the valuable mineral deposits. (c) Los Lomitos. Northward and parallel to the Chiquitas—just as the Chiquitas are parallel to the Sierra, and in the same manner as they subtend the Sierra, is a row of low, rounded, grass-clad hills known as Los Lomitos (the little hills). These are very small, usually not over 100 feet high, but are an important feature of the district.

2. *The Plain.* Looking from the mountains north and eastward can be seen an extensive stretch of sub-level country—the basin of the Rio Grande and Sabinas—the great coal field of northern Mexico. There are several features of this plain which deserve brief mention however; (a) the valley of the Rio Sabinas, which is from 12 to 15 miles north of the mountains, a beautiful stream of great volume, which has worn its way down through the strata to a distance of about 1,000 feet below the base of the mountain, thereby exposing the geological structure of the plain. Remnantal of this great erosion of the Sabinas are several important topographic features; (b) the volcanic mesas, which when viewed from the west, resemble an elongated platform or bench projecting northward from the base of the Chiquitas. Its top is perfectly level, but the precipice which surrounds it is about 100 feet high. (c) Near the northern end of this table land are several disconnected flat-top circular hills (buttes) which are remnant of the former extent of the mesa.

(d) *The Lomas.* At several places in the valley are low hills of yellow sands and clays, the remnants of the valley of the Sabinas, which has cut down into the coal measures constituting the foundation of the plain, upon which the conglomerate and lava have been deposited. To the northwest and across the river these lomas (hills) have considerable extent and form a low range of elevation about 300 feet above the river.

(e) *The Conglomerate Terrace.* Near the base of the mountain, and extending into the valley from one to four miles is a level bench composed of fragments of mountain rock. Wherever this bench or terrace is eroded, beneath it are found the soils used by the agriculturists, irrigated by the streams from the mountains. No doubt this formation once covered most of the plain.

III. GEOLOGIC STRUCTURE OF THE REGION.

(*a*) *The main mass of mountain or Sierra Grande* is composed

Figure 1. *Showing type of monoclinal fold whereby the Sierra Chiquitas were separated from main mountain mass. Section 20 miles north and south.* a-a the hard limestone formation of the mountain. b-b the conglomerate formation of the valley. c-d line of fracture. I. The valley of the Sabinas. II. The Lomitos. III. The Sierra Chiquita, or Hog Backs. IV. The Sierra Grande.

of massive blue-gray and blue-black stratified limestone of great hardness and durability, tilted at slight angles in various directions, and void of any marked folds. No granitic or volcanic rock is anywhere exposed in these, and the rocks which underlie this limestone series are concealed. At least 4,000 feet in thickness of these rocks are exposed, and from the occurrence of characteristic fossils, they are seen to belong to the great system of rocks in Mexico and Texas, known as the Comanche series, and are of Lower Cretaceous and probable Jurassic age, *i. e.*, older and below the Meek and Hayden section of the North American Cretaceous. This is the same system of limestone which composes many of the mountains of the Trans-Pecos region of Texas, and the silver-producing mountains of Mexico and New Mexico, and which occurs in Texas as less indurated chalky strata. These rocks were elevated into their present position at the close of the Upper Cretaceous period, and have undergone much denudation and erosion by subsequent events.

(*b*) *The Sierra Chiquita or hog backs.* This system of small mountains, skirting the north flank of the main mountain mass, and in which the mines are located are a part of and composed of the same rock as the Sierra Grande or main mountain mass, but differ from

them only in arrangement and greater tilting of the strata. They represent the bent and downthrown portion of what is technically known as a faulted monoclinal fold as shown in the accompanying figure. This separated them from the main mountain mass.

The strata of the Sierra Chiquita or Hog Backs stand almost vertically, dipping 80° north and striking 20° south of east. By erosion the Sierra Chiquita which once constituted a continuous ridge, have been separated by canons and given their present serrated and isolated individuality, as shown in the sketch of the mountain range.

Accompanying the great fault which separated the Chiquitas from the Sierra Grande, numerous fissures, joints and all the fractures were made in these smaller mountains at right angles to the strike of their stratification and the main fault, and into these at a subsequent period has been infiltrated the mineral and accompanying vein matter. By this sub-vertical tilting of the strata of the Sierra Chiquita, upward of 5,000 feet of the limestone formation are visible in the canons, which cross them at right angle to the stratification and in the direction of the veins (north and south appproximately).

(*c*) *The Lomitos or Foot Hills.* This range of small hills which run parallel to the Chiquitas, is a product of the same folding which produced the latter, but is of a later age and softer strata, being composed of a thin laminated calcareous shale, of the Upper Cretaceous, which in places is very much metamorphosed, having the appearance of slate, and so called by the miners. In other places they are almost chalky. It is owing to this difference in hardness and structure that they have yielded more readily to the erosion and hence their diminutive size. At the contact plane of this formation of the Lomitos and

Figure 11. SIERRA CHIQUITA. (Non Par.)

that of the harder rocks of the Chiquitas there are often important mineral deposits.

2. *The formation of the plain.* The formation of the valley of the Sabinas or plain which extends northward from the Santa Rosas is entirely different from that of the mountains, and is composed (*a*) of thin, laminated, crumbling, calcareous, arenaceous clays, alternating with strata of thin sand and limestone accompanied by numerous coal beds, lignite beds, silicified trees, fossil molluscs and occasional bones of animals. This is the great coal formation of the Sabinas and belongs geologically to the very latest epoch of the Upper Cretaceous, or Glauconitic Division, and should not be confounded with the lignite beds of the Tertiary period of the eastern United States, but is allied to the coal beds of the Rocky Mountain region as worked in New Mexico, Colorado, Wyoming and Utah, and which is one of the most valuable and important fuel-producing terranes in the world. This coal field is the only one developed in Mexico, and at the mines at San Felipe some twenty miles distant, the coal is obtained for all the railway systems of Mexico, and largely exported into the United States. These rocks are sub-horizontal a few miles from the mountains, but at their contact with them they are uptilted, showing their participation in the uplift, and that the age of the mountains is Post Cretaceous.

Before the erosion which exposed these foundation measures in the plain, they were covered by two later and different formations, which will next be explained. The whole Rio Grande embayment is underlaid by this coal formation which is more fully discussed later.

(*b*) *The Valley Conglomerate or Terraces.* Forming a terrace or bench of the plain for several miles away from the mountains and extending up the canons to a certain level, there is a great sheet of conglomerate lying horizontally and composed of large rounded pebbles of the mountain limestone, cemented by a calcareous matrix. This conglomerate, as exposed by the cutting of the arroyos (dry creeks) and canons, is over 100 feet in thickness and is the shore deposit of the great sheet of water, which in late Quaternary times extended over millions of square miles of western North America, and which is one of the most remarkable features of the continent.

These terraces of the Santa Rosa have their counterpart on the

northern side of the Rio Grande embayment in the great gravel debris and estuarine deposits of that region.

In some of the mines near the contact of this conglomerate and the Chiquitas it forms an important element in excavating and drifting.

(*c*) *The Basaltic or volcanic mesas.* Next to the mountains proper the most conspicuous feature of the region is an elongated tableland or mesa and a few disconnected buttes, which extend northward from the base of the range north of the Chiquitas out into the plain. The summit or table of these is composed of hard black volcanic material, the remnants of a great lava flow which once covered much of the plain, but most of which has since been destroyed by erosion. This lava sheet is not over 100 feet in thickness, and extended up to and against the Chiquitas covering the coal fields unconformably, and having been a most important factor in producing the mineralogical conditions of the area. By its weight and heat the lignites of the Sabinas coal fields were converted into the superb coals, and the metallic fillings of the veins and fissures are apparently connected with it. Far out into the plain towards San Felipe, remnants of this lava flow can be seen, although the source from which it came is unknown, for there are neither craters, fissures, dikes, intrusions or other vents visible in the Santa Rosas (although they have been erroneously reported) and the nearest known to the writer are in Uvalde and adjacent counties of Texas 150 miles distant. Whatever may have been the source of this lava there can be little doubt, from the occurrence of the valuable minerals only in those Chiquitas in its vicinity, that the origin of the minerals is closely connected with its phenomena in comparatively recent geological time.

The Santa Rosas are surrounded on all sides by this plain, and completely disconnected from the other mountain blocks seen to the northwest and east which are all of the same general type of structure, *i.e.*, isolated mountain blocks surrounded by plains. Many of the other ranges have porphyritic and basaltic extrusions, but the Santa Rosa proper is merely a remnantal block of the Cretaceous rock sheets, broken and faulted. It is the simplest of all the mountain blocks of the Basin region, and hence I have selected it for description.

ADDITIONAL NOTES ON THE DEVONIAN ROCKS OF BUCHANAN COUNTY, IOWA.

By S. CALVIN, Iowa City.

The present paper is intended as a preliminary notice of some observations recently made on the Devonian rocks of Buchanan county, Iowa. In the final paper on the subject references to the literature on the Devonian of this part of Iowa, and due credit to those who have previously worked in this field, will be given.

In a paper published in the *Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. IV. Number 3, July 29, 1878*, pp. 725-730. I referred, under the name of *The Independence shales*, to a member of the Devonian series that at that time was supposed to lie at the base of the system in Buchanan county. Later observations render it certain that the Independence shales do not constitute the lowest member of the series, but that they were preceded by brecciated limestone of Devonian age. The thickness of this brecciated limestone so far as it is developed in Buchanan county, has not been ascertained. It is, however, well exposed in the bed of the Wapsipinnicon river at Independence. At Troy Mills, in Linn county, about a mile from the southern boundary of Buchanan, it is again exposed. It may be seen at a number of intermediate points. A very perfect limestone breccia, having an estimated thickness of about thirty feet, and belonging probably to the same horizon as the brecciated limestones of Buchanan county, is exposed in a deep railway cut at Fayette, Iowa.

So far then as Buchanan county is concerned the exposed strata are:

1. *Brecciated limestone.* No fossils have as yet been seen in these beds at Independence, but at Troy Mills in Linn county, they contain many brachiopods that are characteristic of the lower part of the Iowa Devonian.

2. *The Independence shales*, composed largely of bluish shales with some layers that are black and highly carbonaceous, and containing occasional pyritized plant stems and fragments of coal. The peculiar fauna of these shales and its interesting relation to the fauna of the Rockford shales along Lime creek in Floyd and Cerro Gordo counties has been discussed in the article above cited.

3. *Gyroceras beds.* These are beds of rather hard, compact limestone a few feet in thickness and containing numerous specimens of a large *Gyroceras* with which are associated robust forms of *Gypidula occidentalis* Hall, or *Pentamerus comis* Owen, of Walcott and some other authors.

It may be interesting to state that this same *Gyroceras* and similar robust forms of *Gypidula* occur in the brecciated limestone at Troy Mills. About a mile east of Independence the *Gyroceras* beds may be seen resting on the Independence shales. In the old Kilduff quarry, northeast of the city, where the shales were explored for coal, the Gyroceras beds were penetrated, and the "petrified snakes" attracted much attention.

4. Spirifera pennata beds. At Independence these beds are about twenty-five feet in thickness and consist of light-colored, soft, argillaceous limestones. *Spirifera pennata* Owen, is the characteristic fossil, but associated with it are *S. bimesialis* Hall, *Atrypa reticularis* Linn, *A. aspera* var. *occidentalis* Hall var., *Cyrtina hamiltonensis* Hall, *Productella alata* Hall, *Gypidula occidentalis* Hall, *Orthis iowensis* Hall, *Orthis macfarlanei* Meek, *Strophodonta demissa* Conrad, a large undescribed *Chonetes* and a few other forms. The fossils are almost exclusively brachiopods. The *Atrypa reticularis* is a very finely ribbed variety with a tendency to become alate at the cardino-lateral angles, and having a form that is decidedly lenticular, particularly in the young and half grown individuals. The *Cyrtina hamiltonensis* is identical in size and shape with the form found in the Hamilton strata of New York and western Ontario. The *Strophodonta demissa* is a small, short-hinged, arcuate form, with broad flattened ribs. The Spirifera pennata beds are seen in the banks of the stream at Otterville, a few miles north of Independence. They are also seen on the west side of the river near Quasqueton, ten miles to the southeast; at a number of exposures near Troy Mills, eight miles farther to the southeast and at intermediate points. Some of the layers included under number 4, are destitute of fossils, but the species enumerated will be found both above and below the barren layers.

5. *Acervularia profunda beds.* At Independence the Spirifera pennata beds grade upwards into beds of harder limestone in which brachiopods are scarce and corals of a variety of species predominate. *Cystiphyllum americanum* Ed. and H. is at first the most abundant. With it, however, occurs very sparingly *Heliophyllum halli* Ed. and H. There is also a Cyathophyllum or two, and eventually large numbers of *Acervularia profunda* Hall. Within the limits of the city of Independence the uppermost layers usually reach only into the zone of Cystiphyllums, but occasionally the upper beds include *Acervularia profunda*. From a mile to a mile and a half east of the city this last species is quite abundant. At a quarry near Jesup, about nine miles west of Independence the A. profunda beds are well developed, but it is at Littleton, about ten miles northwest from Independence, that they are seen in greatest perfection. About a mile south of Littleton a " dry run," that becomes quite a torrent in rainy weather and at other times is a mere dry channel, has cut into the A. profunda beds. The matrix here is much softer than at Independence and the corals are beautifully weathered out. Along with *A. profunda* occur excellent specimens of *Cystiphyllum*, *Cyathophyllum*, *Zaphrentis*, *Favosites*, *Cladopora*, *Cœnites*, *Stromatopora* and other genera. At Independence the corals separate from the matrix with extreme difficulty and satisfactory specimens are rarely obtained. In the banks of

the river, just below the mill at Littleton, the Acervularia profunda beds rise only a few feet above the level of the water. Farther down the stream they are better exposed.

6. *Acervularia davidsoni beds.* These beds lie upon the A. profunda beds. The transition from one species of Acervularia to the other is very abrupt. There are layers crowded with *A. profunda* Hall, in the lower part of the bank of the river, and two or three feet higher the rock is simply a compacted mass of *A. davidsoni* Ed. and H. The two species never occupy the same layer, and furthermore the two are here as distinct as any two species of the same genus could be by any reasonable possibility. In mode of growth, size and depth and essential characteristics of the calyces of the individual corallites, development of the septa, and indeed in all particulars that make up specific distinctions, *A. profunda* Hall, and *A. davidsoni* Ed. and H., are at least at Littleton, Iowa, specifically far apart. This much is said for the reason that so eminent an authority as Rominger regards *A. profunda* as merely a variety of the species *A. davidsoni.*

In layers associated with the A. davidsoni beds, though not in the same layers with the corals, are found specimens of *Spirifera parryana* Hall. As I have elsewhere observed* the beds that furnish *S. parryana* always lie above those in which *S. pennata* occurs. This relation is well illustrated in the rocks of Buchanan county. Along with A. davidsoni occur a number of species of *Favosites* and one species of *Chonophyllum.* The same *Favosites* and *Chonophyllum* are associated with *A. davidsoni* and *S. parryana* at Iowa City, in Johnson county, Iowa. The A. davidsoni beds at Littleton furnish some beautiful examples of *Pentamerella dubia* Hall, a species that occurs at the same horizon near Iowa City. Neither *Atrypa aspera* nor any form of spiniferous Atrypa, is known from beds, number 6, either in Buchanan county or elsewhere in Iowa. These beds with their *A. davidsoni, Favosites, Spirifera parryana,* and other distinguishing characteristics are well developed along Lime creek, near Brandon, in the southeast corner of Buchanan county.

7. *Yellow shale beds.* At a considerable distance above the A. davidsoni beds, with probably some characteristic beds between, occurs a bed of yellow colored shales. These shales are exposed well up in the river bank below the mill at Littleton. The fauna is peculiar in this respect, that nearly all the forms are strangely modified. *Atrypa reticularis* Linn, is very coarsely ribbed, with the ventral valve flat or concave and the dorsal valve excessively gibbous, contrasting strongly with the form from the Spirifera pennata beds. *Strophodonta demissa* Con., is large, the hinge line often exceeding two inches, and the width of the shell frequently more than twice the length. *Cyrtina hamiltonensis* Hall, is a diminutive affair having, on an average, less than one-fourth the normal dimensions. A Spirifer which may be a modified *S. parryana*, but deserving to rank as a distinct species, has the hinge area much narrower

***Notes on the Synonymy, Characters and Distribution of Spirifera parryana* Hall. *Bulletin from the Laboratories of Natural History of the State University of Iowa. Vol. I. No. 1*, p. 25 et seq.

than in *S. parryana*, and the mesial fold divided by a deep groove. These beds also furnish a Terebratula that may be representative of *T. iowensis* Calvin, found in association with *S. parryana* near Fayette, Iowa. An Orthis related to *O. iowensis* Hall, a small, undetermined Rhynchonella and numerous stems of Striatopora, complete so far as observed the fauna of beds, number 7.

In addition to the seven beds here recognized the Devonian of Buchanan county embraces beds containing *Rensselaria johanni* Hall and Whitfield, but the relation of the Rensselaria beds to the beds above described has not been definitely ascertained. Rocks with Rensselaria are in place at Fairbanks above Littleton, and some detached fragments containing this genus were found at Littleton and at Jesup.

The fossils found in numbers 5, 6, and 7 resemble very closely the assemblage of species cited by Messrs. Hall and Whitfield in the twenty-third report on the state cabinet of New York, p. 224, as occurring at Waterloo, Iowa. The Spirifer from the shale beds, number 7, sometimes resembles very closely *S. oweni* and again it is not unlike certain forms of *S. manni*. In the paper cited, p. 225, Hall and Whitfield infer that the Waterloo beds are more nearly related to the Upper Helderberg limestones of New York, while the Independence beds that contain *Spirifera pennata* may in their judgment be the representative of the New York Hamilton. The observations set forth in this paper clearly demonstrate that the coral bearing beds at Waterloo are younger than the Spirifera pennata beds at Independence.

THE ICE-SHEET OF GREENLAND.

By Warren Upham, Somerville, Mass.

A Reconnoissance of the Greenland Inland Ice. R. E. Peary, Civil Engineer, U. S. Navy. Bulletin of the American Geographical Society, vol. xix, pp. 261-289, Sept. 30, 1887.

The Glaciers of Greenland. Prof. G. F. Wright, The Ice Age in North America, chap. iv, pp. 67-91. (D. Appleton & Co., 1889.)

The First Crossing of Greenland. By Fridtjof Nansen. Vol. i, pp. xxii, 510; with 3 maps, 7 plates, and 78 woodcuts in the text. Vol. ii, pp. x, 509; with 2 maps, 5 plates, and 73 woodcuts. (London: Longmans, Green & Co., 1890.)

A proposed Exploration of northern Greenland. An address before the American Geographical Society, April 13, 1891, by R. E. Peary, U. S. N. Bull., Am. Geog. Soc., vol. xxiii, pp. 157-171, June 30, 1891.

Journeys on the Inland Ice. Compiled by GEORGE C. HURLBUT, Librarian of the Society. Ibid., pp. 171-193.

The Party and the Outfit for the Greenland Journey. By R. E. PEARY. Ibid., pp. 256-265.

Many questions concerning the glacial drift and the Pleistocene ice-sheets of North America and Europe have recently received much illumination, with promise of more in the near future, from contributions to our knowledge of the ice covering the interior of Greenland. Wherever that country has been explored, the edge of an ice-sheet is reached within distances varying from a few miles to fifty or rarely a hundred miles back from the coast; and the icebergs of the North Atlantic are supplied by the glaciers which descend from this inland ice to the heads of the long and narrow, deep fjords, and in part by tracts of the broad ice-sheet itself where it extends quite to the outer coast line and terminates in the open sea. Peary estimates the area of Greenland to be about 750,000 square miles, of which he believes that four-fifths or about 600,000 square miles are thus ice-enveloped. The Antarctic ice-sheet, however, surrounding the south pole, is nearly ten times larger than this; and in the Pleistocene period both the North American and European ice-sheets occupied areas more extensive than the inland ice of Greenland, though less than the southern polar ice-cap.

Comparing the existing with the ancient ice-sheets, the low borders of the Antarctic lands, covered with a vast expanse of ice which stretches far into the sea and is broken off in tabular or broad and flat bergs, may be supposed to represent nearly the Pleistocene ice-front as it was pushed into the Atlantic on one side from southern Norway, from the basin of the North sea, from Scotland, the Hebrides, and Ireland, and, on the other side, from Newfoundland, Nova Scotia, and the eastern shore of New England. But the mountainous borders of Greenland, discharging icebergs of every irregular shape from its fjords and from portions of the ice-sheet that here and there reach to the ocean, seem to fall short of the grandeur of all the seaward limits of the old ice-sheets, though most nearly resembling their development on the rugged shores of northern Norway, of northern Labrador, and of British Columbia, where the ice flowed through gaps of the mountains forming these coasts and their islands and terminated beyond the present seaboard.

Professor Wright's chapter, "The Glaciers of Greenland," well reviews the early explorations, previous to Peary, including the journeys and writings of Nordenskiöld, Jensen, Helland, Rink, Kane, Hayes, Whymper, and others. The most important of these journeys were by Nordenskiöld, in 1870 and again in 1883, the former being reported in the Geological Magazine, vol. ix, 1872, and the latter in Science, vol. ii, Dec. 7, 1883. Distances, however, were much overestimated in these reports, and appear to be more reliably given by Nansen in his chapter describing the explorations of the inland ice previous to his own memorable crossing of Greenland.

Nordenskiöld's journey in July, 1870, to the east from the head of Aulatsivik fjord, near lat. 68° 20′, is estimated to have extended about 35 miles upon the ice-sheet, and the altitude reached was 2,200 feet. Large streams on the ice-surface were encountered, "which could not be crossed without a bridge." Beyond the point of turning back, "the inland ice continued constantly to rise towards the interior, so that the horizon towards the east, north, and south, was terminated by an ice-border almost as smooth as that of the ocean." A fine, gray powder, called "cryoconite," which was believed by Nordenskiöld to be cosmic dust, was found on the ice; but analyses indicate that this is dust blown from the mountains of the coast, and it does not occur in noticeable amount, according to Nansen, on the eastern portion of the ice-sheet where his ascent was made upon ice bordered by only little bare land.

From nearly the same starting point, Nordenskiöld in July, 1883, went onto the ice-sheet about 73 miles, to a height of about 4,950 feet; and two Lapps, travelling with the peculiar snowshoes called "ski," advanced a probable distance of 45 or 50 miles farther, where the barometers indicated a height of 6,386 feet. Land in the interior, free of ice and bearing vegetation, which Nordenskiöld hoped to reach, was not found; and no nunatak, or projecting top of hill or mountain, above the ice-surface has been yet discovered more than forty or fifty miles inside the ice-covered area.

Robert E. Peary, in June and July, 1886, accompanied by Christian Maigaard, made the next important exploration of the inland ice, going east from the head of Pakitsok fjord on the northeast part of Disco bay, in lat. 69° 30′. These explorers

advanced to a distance of about 100 miles from the edge of the ice, attaining an altitude of about 7,500 feet. Describing the first ten miles of the ice, Peary writes:—"In detail, the surface was, as a rule, roughly granular in texture, affording firm, sure footing, interrupted here and there by crevasses, some open and some covered with a snow arch by patches of soft, deep snow in the depressions between the hummocks, and by patches of hard ice cut by nearly parallel furrows, as if made by a huge plough." The camp at the end of their advance was in a shallow basin of the *névé* of snow which covers all the inner portion of the ice-sheet, there having, to use Peary's words, "the consistency of fine granulated sugar as far down as I could force my alpenstock (some six feet)."

The margin and the interior of the ice-sheet are characterized by Peary as follows:

> Wherever the ice projects down a valley in a long tongue or stream, the edges contract and shrink away from the warmer rocks on each side, leaving a deep canon between, usually occupied by a glacier stream. * * * * Higher up, along the unbroken portions of the dam [*i. e.* enclosing mountains] where the rocks have a southern exposure or rise much above the ice, there is apt to be a deep canon between the ice and the rocks; the ice-face sometimes 60 feet high, pure, pale-green, and flinty. In another place the ice-face may be so striated and discolored as to be a precise counterpart of the rock opposite, looking as if torn from it by some convulsion. The bottom of the canon is almost invariably occupied by water. * * * * Still farther up, at the very crest of the dam, the ice lies smoothly against the rocks.
>
> As to the features of the interior beyond the coast-line, the surface of the "ice-blink" near the margin is a succession of rounded hummocks, steepest and highest on their landward sides, which are sometimes precipitous. Farther in, these hummocks merge into long flat swells, which in turn decrease in height towards the interior, until at last a flat, gently rising plain is reached, which doubtless becomes ultimately level.

In concluding the narrative of this journey, after describing the needful outfit, Peary remarked:—"To a small party thus equipped, and possessed of the right mettle, the deep, dry, unchanging snow of the interior * * * is an imperial highway, over which a direct course can be taken to the east coast." It is also suggested that the unexplored northern shore lines of Greenland may be most readily mapped by expeditions across the high inland ice.

Two years later, in August and September, 1888, Dr. Fridtjof Nansen, with five companions, crossed this ice-sheet from east to west, between lat. 64° 10′ and 64° 45′. The width of the ice there is about 275 miles, extending into the ocean on the east, but terminating on the west about 14 miles from the head of Ameralik fjord and 70 miles from the outer coast line. For the first 15 miles in the ascent from the east, rising to the altitude of 1,000 meters, or 3,280 feet, the average gradient was nearly 220 feet per mile. In the next 35 miles an altitude of 2,000 meters, or 6,560 feet, was reached; and the average gradient in this distance, between 15 and 50 miles from the margin of the ice, was thus about 94 feet per mile, or a slope very slightly exceeding one degree. The highest part of the ice-sheet, about 112 miles from the point of starting, was found to have an altitude of 2,718 meters, or about 8,920 feet. Its ascending slope, therefore, in the distance from 50 to 112 miles was about 38 feet per mile. Thence descending westward, the gradients are less steep, averaging about 25 feet per mile for nearly 100 miles to the altitude of 2,000 meters, about 63 feet per mile for the next 52 miles of distance and 1,000 meters of descent, and about 125 feet per mile for the lower western border of the ice.

The narrative of this expedition is most admirably told by Dr. Nansen in two well illustrated volumes, entitled "The First Crossing of Greenland." The scientific results attained are presented in an appendix of the second volume, from which the following extracts are quoted:

As to the superficial aspect of the inland ice, I may say, in the first place, that of crevasses we found a surprisingly small number in the course of our journey. On the east side they occurred only in the first seven or eight miles; on the west side we came across the first fissure at some twenty-five miles from the margin of the ice. In the interior there was no trace of them.

Of surface rivers we found practically none. Some may be inclined to think that this was due to the lateness of the season, though this objection has little force, seeing that the middle of August, when we were on the east side, is not late in the season as far as regards the melting of the snow, and furthermore, that even if the rivers had disappeared themselves on the west coast, we should have seen traces of their channels. None such did we see in the interior at all, and the first we observed were not more than fifteen or twenty miles distant from the western edge. It is possible, also, that there were minor brooks on the surface in the first ten miles from the eastern side. Except for these

small water-courses near the two coasts, I may say positively that there are no rivers at any time of the year on that part of the inland ice over which we passed.

* * * At no great distance from the east coast the surface of dry snow begins, on which the sun has no other effect than to form a thin crust of ice. The whole of the surface of the interior is precisely the same. * *

Of moraine débris or erratic blocks we met with none upon the ice with the exception of the last little slope when we left it for good on the western side, or no more than a hundred yards from the extreme edge. * * *

* * * Some of the temperatures which we experienced were far lower than the established meteorological laws could have led us to expect. * * * * The temperature on certain nights, September 12 and 14, probably fell, according to the calculations of Professor Mohn, to—45° Cent. (—49° Fahr.), while the mean temperature of certain days, September 11-16, when we were about in the middle of the country, or a little to the west of the highest ridge, varied from—30° Cent. to—34° Cent. (—22° to—29° Fahr.). This is at least 20° Cent. (36° Fahr.) lower than anyone would have been justified in expecting, if he had based his calculations on accepted laws, taking for his data elevation above and distance from the sea, as well as the mean temperature of the neighboring coasts.

* * * In the forty days which we spent on the ice there were sixteen of either snow or rain. On four days only did we have rain, when we were weather-bound in the tent near the east coast, and on one day near the west coast we had hail; on the rest it was always snow, which in the interior took the form of fine 'frost snow,' or needles of ice. This fell almost daily out of a half-transparent mist, through which we could often see the sun, together with halos and mock-suns.

Though the ice-sheet of Greenland has formerly been more extended and deeper than now, as is shown by glaciation of the rock surface high up on the sides of the fjords, it has probably during several centuries been on the increase. There can be little doubt that the climate at present is prevailingly colder than during the prosperous period of the Norse colonies between 900 and 500 years ago. By its increasing accumulation, therefore, we may account for the contrast between the Greenland ice, which has so little englacial and superglacial drift, even near its edge, and the partially drift-buried Malaspina glacier at the foot of the Mt. St. Elias range (AM. GEOLOGIST, vol. vii, pp. 33, 141); for there, according to Russell, the ice has probably been on the wane during the past 500 or 1,000 years and at present is somewhat rapidly receding.

Neither Peary nor Nansen is willing to rest on laurels already

won. On June 6th of this year, with five young men and his wife to share the perils of this expedition, Peary sailed from New York for Whale sound, western Greenland. After advancing to the Humboldt glacier and establishing a depot of supplies there, his plan is to return and spend the winter at Whale sound, in the vicinity of friendly Eskimos. In the summer of 1892, he will set out with sledges and dogs toward the northeast upon the inland ice. Portions of the supplies will be left on the route northward at Petermann fjord and the Sherard Osborn and Meigs fjords, and thence the party will push forward, as is hoped, to the extreme northern point of Greenland, an estimated total distance of about 600 miles from the Humboldt glacier. Peary expects to accomplish this journey and the return within ten weeks, travelling fifteen to twenty miles per day; and he hopes to reach Whale sound again in season for passage home on some whaler before winter.

Nansen's plan for an Arctic voyage of perhaps five years, starting early in 1892, is explained by himself in The Forum (August, 1891, pp. 693-709, with map,—followed by an unhesitatingly adverse criticism, by Gen. A. W. Greely, pp. 710-716). With a crew of ten or twelve, Nansen proposes to sail through Bering strait and thence northwestward nearly in the course of the ill-fated "Jeannette," until the marine current is reached by which drift-wood from Siberian rivers is borne away to be stranded in Greenland, and by which also an ice-floe, with relics of the Jeannette expedition upon it, was carried in three years by some passage across the polar ocean to the southwest coast of Greenland near Julianshaab. Taking this current, with the ship frozen in the floe-ice during winter, Nansen hopes to drift by the near neighborhood of the pole and southward along the east coast of Greenland; for the floe mentioned, bearing articles from the Jeannette, is believed to have passed around Cape Farewell. If the ship should be lost, the party will encamp on the floe-ice with their provisions and boats, and will expect thus to reach perchance some inhabited portion of the Greenland coast.

Both these expeditions are to be led by young men, whose enthusiasm is heightened by their previous success in similar tasks; and the experience thus acquired will all be needed for these enterprises of so much greater difficulty and danger. In wishing to them each "Bon voyage!" we cannot do otherwise

than admire their splendid courage and devotion to science; but at the same time we cannot fail to remember the proverb, "There's many a slip 'twixt the cup and the lip," for no other conditions could more suggest it than the slippery, crevassed ice-sheet, and pinching, crushing ice-floes of great thickness and piled together, driven capriciously by winds and sea currents.

AN EPISODE IN THE PALÆOZOIC HISTORY OF PENNSYLVANIA.

E. W. CLAYPOLE, Akron, O.

In an article printed in THE GEOLOGIST for the month of April, 1890, the writer sketched the palæozoic history of Pennsylvania. The sketch was the merest outline. Superficial it could not but be, for our knowledge of the subject at present warrants no more ambitious attempt. All details were omitted, indeed few are known. Whole chapters of geological history will one day be written on these as they gradually come to light, but at present a dense darkness hangs over the field allowing but a dim view of the most prominent features of the landscape.

One of these details, forming a single episode in the palæozoic history of the Keystone State, will be the burden of this paper—an episode that may help us to realize the immense length of palæozoic time and the complexity of palæozoic history.

Among the Devonian strata that are conspicuous for their extent, thickness and fossil treasures, is the Hamilton group, so named by Prof. Hall. This group, as known in western New York, is for the most part a mass of shales enclosing a thin bed of limestone—the Encrinal limestone—and capped by another thin bed—the Tully limestone. It is thus arranged:

4. Tully limestone.
3. Moscow shales.
2. Encrinal limestone.
1. Blue shale.

This is the original and typical section of the Hamilton group. But from this it varies even within the limits of the state of New York. Eastwardly it contains a thin bed of sandstone from which the excellent flagging quarried on the Hudson near Kingston, etc., is taken, and still farther east in Maine and New Brunswick the shale gives place almost entirely to sandstone.

A similar departure from the type occurs in middle Pennsylvania. There, in Perry county for example, the Hamilton comprises a lower shale followed by a massive sandstone on which lies an upper shale closely resembling the lower in texture, material and general appearance. No limestone is present.

The section therefore in detail is as follows :

Hamilton upper shale	250 feet
" sandstone	800 "
" lower shale	450 "
	1,500 "

The intercalation of this enormous mass of hard sandstone in the Hamilton group gives it a strange aspect to one only accustomed to see it as it appears in New York. As may be inferred it changes the character of the surface where it crops out from a gentle rolling rounded contour to one, rough, wild and wooded and generally incapable of cultivation.

This sandstone prevails over several counties but reaches its maximum thickness in Perry Co., where it is thus described in the writer's report (F_2 of the Geological Survey of Pennsylvania).

"The Hamilton sandstone is one of the most remarkable formations of Perry county. Lying in the midst of a vast mass of shale it has the appearance of being out of place to the geologist accustomed to look on the Hamilton as essentially a soft group.

"It forms numerous mountains in the county, Turkey ridge, Buffalo ridge, Mahanoy ridge, Dick's hill with its continuation, Rock hill, also Pisgah hill and Little mountain are all formed by outcrops of this sandstone. Some of these are high, rough and untillable; others are comparatively smooth and accessible. This difference is due to two causes —the hardness and the dip of the sandstone. The proportion of sand also rapidly diminishes to the north and west especially in the middle of the bed, diminishing the steepness and roughness of the ridges.

"At its southeastern exposure near Marysville this sandstone attains its greatest thickness and hardness—a thickness amounting to 800 feet. From this point it gradually thins away, the upper and lower beds persisting farthest and the intermediate shale becoming constantly thicker until at length it becomes two distinct sandstones with an intervening bed of softer material. This change may be detected in Perry county. At Montebello Narrows the Little Juniata has cut its way through the lower beds and has then flowed for nearly half a mile parallel to the ridge and between the two sandstones, at length crossing the upper and thus producing a zigzag channel. But outside the limits of the county the change becomes more manifest. At and near Huntingdon the two sand layers may be distinctly traced only a few yards thick, the upper being the heavier. The great mass of the bed has become shaly. This

is only 60 miles from its point of greatest development on the Susquehana.

"The Hamilton sandstone is therefore a mass of coarse siliceous material intercalated near the middle of the group and spreading fanwise as from a center near Marysville, dying away and at length disappearing as it receded from the point." (p. 57.)

This will give a general description of the structure and mass of the Hamilton sandstone. The following is from Prof. I. C. White's report of Huntingdon county, and shows how the stratum occurs there. T_3 p. 105.

Hamilton upper shale		250 feet
" upper sandstone		30 "
" middle shale		225 "
" lower sandstone	(hard)	50 "
" lower shale		75 "

Thus we see that the massive Hamilton sandstone of Perry Co., 800 feet in thickness, has in Huntingdon Co. dwindled down to two comparatively insignificant sheets of 50 and 75 feet thick respectively and separated by 225 feet of shale.

The same type of structure is shown in Northumberland and adjoining counties as we find from Prof. White's report (G_7 p. 77, etc.) He says in speaking of the country east of the eastern branch of the Susquehana :

"The type of the Hamilton series is remarkably similar to the corresponding beds in western New York both in lithology and in the accompanying fossils."

Again he writes : "The middle type of the Hamilton comes in after passing south from the Northumberland synclinal and may be found on both sides of the Selinsgrove arch which crosses the river about five miles below Sunbury. The section on the south side of that axis exhibits a structure for the Hamilton quite different from that shown in Columbia county."

Olive-brown shales	450 feet
Selinsgrove upper sandstone	202 "
Dark olive shales	125 "
Selinsgrove lower sandstone	5 "
Brown and dark shales	800 "

Again Prof. White writes : "The southern type of the Hamilton beds is reached after passing south of the Georgetown axis near the southern border of Northumberland there being a progressive coarsening of the series in that direction from the locality of the last section near Selinsgrove."

Selinsgrove upper sandstone	100 feet
Olive-brown shales	300 "
Selinsgrove lower sandstone	50 "

Prof. White adds: "The Selinsgrove upper sandstone is one of those intercalated beds which here makes its appearance in the middle of the Hamilton group and is so thick and massive as to change entirely the character of the topography, for instead of a wide level valley as in the north, it is now found making a high ridge along the strike of this sandstone. There is not an inch of this sandstone represented in the bed on Fishing creek. (Fishing creek drains nearly all of Columbia Co. north of the Susquehana and is therefore to the northeast of Northumberland Co.)"

Again we find in Mr. Platt's report on Blair Co. the following evidence. (T_3 p. 31):

"In Blair Co. the whole of the Hamilton formation is composed of dark shale with calcareous layers."

And further Prof. Lesley adds a note in the report of Rye township (F_2 p. 310) to this effect:

"The outcrop of the Hamilton sandstone crosses the Susquehanna river eastward from Perry Co., and runs through Dauphin, Lebanon and Schuylkill counties," that is northeastward.

It thus appears that the Hamilton sandstone gradually thins away from a point near or on the south line of Perry Co., to the northeast, north and northwest, in which directions alone it can be traced. In thus thinning out it splits and becomes a lower and an upper sheet of which the latter is the more persistent, extending even into Northumberland, while both underlie much of Huntingdon Co. Its color is usually gray or whitish, seldom yellow and never red, and it is usually not very hard. It is not conglomeratic.

At the south line of Perry Co. it stands vertical and is even somewhat overthrown as may be seen upon the Susquehanna a few miles north of Harrisburg. When this is the case it forms very rough and almost mountain territory. Its southernmost outcrop is known as Little mountain and is cut by the Pennsylvania Railway near the bridge across the Susquehanna at Rockville.

How much farther it may have extended to the southeast is of course unknown. The contortion and erosion which the country has suffered since its deposition have utterly destroyed all trace of it. Moreover along the line of its last southern outcrop in Little mountain lies apparently the edge of a great overthrust plain which has brought the Onondaga red shale against the Hamilton sandstone, cutting out, that is covering up, the intervening strata though a thousand feet in thickness. These only reappear to the

eastward near the Labanon Co. line after a concealment of 20 miles.

So large a semilenticular mass of sandstone intercalated in a group of soft strata must have had some local cause and in seeking this we may be aided by recalling the geography of Pennsylvania at the time under consideration.

In the early Devonian era the interior states, generally speaking, consisted of an open ocean extending from the Atlantic land on the east in what is now eastern Pennsylvania to an unknown distance westward and limited to the northward by the Archæan Highlands of Canada. In this palæozoic ocean a gentle elevation was taking place along a line from northeast to southwest through Ohio, whereby what is now known as the Cincinnati ridge or arch was brought into existence. Ultimately, and probably before the Devonian era closed, this ridge partly severed the eastern portion of this ocean from the rest and formed the Appalachian strait or gulf. The continued subsidence of this strait or gulf allowed the deposition in it of sediment from the adjoining land on the east but the nature of the sediment on the area now in question would indicate by its fineness, being mostly sandy shale, that the land was not very near, or if near not very high. The latter is more probable. Such deposits do not indicate shallow water or strong currents. The actual margin of the Appalachian gulf or strait has apparently been destroyed by the corrugation and erosion that have ensued, so that the present Hamilton deposits are those which were deposited off shore, but neither in deep water nor on the border of the land.

But so great and sudden a change in the nature of the strata implies some great and corresponding change in the physical geography and especially in the attitude of the land—a change that would allow the Hamilton sea to assort and arrange coarse sand where it had previously deposited only fine shale.

The arrangement of this sand appears to indicate a center of distribution from which it was spread over the whole area that it now occupies and it seems a not improbable supposition that this centre was the mouth of some large river which bore into the Appalachian sea its tribute of sand and mud. The former was assorted and distributed over the region around the river-mouth, and the latter carried out to a greater distance where it ultimately became a bed of shale. That the ancient Atlantic land was drained by a system of streams goes without saying, and it may be that

we here catch a glimpse of one of them, or at least of the place where it entered the sea.

In making this supposition to explain the occurrence of the Hamilton sandstone, it is not at all necessary to assume that this ancient river came into existence at that epoch and then passed out of being. Far from it. The river may have existed ages before that day and may have continued to flow long after the Hamilton era passed away. All that is necessary is to suppose an accession to its carrying power. And this is not difficult. The palæozoic geology of the eastern states indicates beyond all doubt constant and great oscillation of the land and the seabed. Intermittent depression to immense extent caused the accumulation of the massive sediment of that era. Such accumulation likewise indirectly proves elevation of the land, for had not this taken place the whole area must have been eroded and removed. It is less easy to detect elevation of the land than depression of the sea bottom, because the former leaves no direct evidence of its occurrence. But if the Hamilton sandstone is in truth the monument of some old and extinct river, it records a time when through elevation of the coast the eroding and carrying power of that river were largely increased so as to form the Hamilton lower sandstone. Next it indicates a time when probably by the work of the river, but possibly by ensuing subsidence, the current was again slowed down and the sand dropped near shore, its quantity being also diminished. Thirdly, it reveals another sharpening of the stream by a second elevation whereby it was enabled to erode from the land and scatter over the ocean bed the Hamilton upper sandstone thicker than the lower. Lastly, the action of the river destroyed its own velocity by eroding its channel or a second subsidence ensued with the same effect.

All these episodes are to be read with great probability in the Hamilton sandstone, and if our argument is well founded we gain a peep at one of the changes of which the palæozoic era was made up.

Possibly though this is little more than a supposition; the absence of lime from the Devonian formation through this part of Pennsylvania may be an indication in the same direction. The beds show a preponderance of the earthy and mechanical over the chemical deposits such as is [illegible]al near the mouth of a river where the wash from the land pred[illegible]a[illegible] over all other materials.

The fauna of the Hamilton in middle Pennsylvania contains the following species:

Brachiopoda.

Spirifera ziczac Hall.	Strophodonta perplana Con.
" mucronata Hall.	Strophomena rhomboidalis Wahl.
" medialis Hall.	Orthis penelope Hall.
" acuminata Hall.	Chonetes setigerus Hall.
" granulifera Hall.	" coronatus Con.
Rhynchonella horsfordi Hall.	Tropidoleptus carinatus Hall.
" congregata Conrad.	Atrypa reticularis L.

Rensselæria sp.

Pteropoda.

Tentaculites attenuatus Hall.

Lamellibranchiata.

Glyptodesma rectum Con. Actinodesma subrectum Whit.

Aviculopecten princeps Con.

Gasteropoda.

Loxonema delphicola Hall.

Echinodermata.

Ancyrocrinus bulbosus Hall.

Cephalopoda.

Nautilus liratus Hall.

Crustacea.

Phacops rana Green. Homalonotus delphinocephalus Green.

Vertebrata.

Coccosteus ?

Most of these fossils are forms which would be naturally looked for by the palæontologist in a middle Devonian formation. They characterize the Hamilton group of Pennsylvania and adjoining states. But there are one or two on the list which are less familiar on this horizon and require a moment's notice.

Rensselæria is one of those genera whose existence, even including its allied forms, Amphigenia and Newberria, is, so far as yet known, confined between the limits of the Lower Helderberg below and the Corniferous limestone above. *Rensselæria* was established in 1859 by Prof. Hall to receive a number of peculiar shells of the type of R. ovoides. In 1867 one of these was removed by the author of the genus and made the type of the new genus *Amphigenia*. The range of these was as follows:

Corniferous limestone	Amphigenia elongata.
	Rensselæria johanni.
Schoharie grit	Amphigenia elongata.
Oriskany sandstone	Amphigenia curta.
	Rensselæria condoni.

	R. cumberlandiæ.
	R. intermedia.
	R. marylandica.
	R. ovalis.
	R. ovoides.
	R. suessana.
Lower Helderberg	R. æquiradiata.
	R. elliptica.
	R. lævis Hall.
	R. mutabilis.
	R. portlandica.

Prof. Hall has recently taken his *R. johanni* from its old position and has made it the type of a new genus *Newberria*, characterized by the slightness or absence of external radial striation of the two strong dental plates, and the thick hinge plate and internal loop of *Rensselæria*. To this new genus is also referred the *R. lævis* of Meek which is reported by Whiteaves from several places in the Mackenzie River district.*

When the writer, at the meeting of the Am. Ass. for the Adv. of Science at Minneapolis, in 1883, announced his discovery of these fossils in the Hamilton sandstone, he spoke of the difficulty which he had felt in separating them from some of Prof. Hall's species, such as R. marylandica and R. johanni. He was not willing in this state of uncertainty to coin a new name and left the matter in doubt. These fossils are now in the hands of Prof. Hall for description and the difficulty will doubtless be cleared up. It may very probably prove that they will also belong to the new genus Newberria from their close resemblance to R. johanni. Whether this should prove to be the case or not, they will at any rate carry this type of shell up from the Corniferous limestone to the middle of the Hamilton.

The last name on the list also calls for a short notice. It is a cast of the dorso-median plate of *Coccosteus* or some nearly allied placoderm, but its exact relationship has not yet been determined. Its occurrence in these beds is interesting because, so far as I am aware, no fish fossil has yet been described from the Hamilton group in Pennsylvania, though a scanty fish fauna has come to light from the rocks of similar age in adjoining states. At some future time more details may be given regarding this solitary specimen.

---

*See Contributions to Canadian Palæontology. Vol. I, pt. 3.

NEOLITHIC MAN IN NICARAGUA.

By J. CRAWFORD, Managua, Nicaragua.

Numerous evidences of panic and fright among men and domestic animals in Nicaragua, in one of the past geological epochs, are deeply impressed on stratified rocks many feet below the earth's surface, under the city of Managua, extending south and southeastward from lake Managua to a distance of over one mile, possibly further, as far as has been examined, in the direction of the extinct volcano Masaya (1), ten miles distant. The footprints indicate haste, confusion and excitement, and are impressed from 1½ to 2 inches deep in the stratum, the toes of the feet in every footprint made the deepest mark and pushed the mud back toward the heel, as usual from running in shallow mud; all are pointed, many directly, others obliquely, toward lake Managua, as if to seek shelter in its waters from a storm of burning hot volcanic ashes and cinders, or some equally dangerous occurrence. A few roughly polished arrow heads and barbed harpoons, but no skeletons nor bones have been found in that nor in any of the superimposed strata(2).

A short topographic and stratigraphic description of the locality will enable a comparison to be made with similar conditions of

(1) This volcanic classification of " extinct " is not based on any theory about the interior constitution of the earth, but, on such facts of my own observation as, when in my examinations I found that I must adopt some classification. The plane of invariable annual (also daily) temperature beneath the earth's surface on and near to this large mass of volcanic materials is isogeothermal with planes of similar situations and altitude in that country; on inactive but not extinct volcanic masses no isogeothermal plane can be found, or, it is too irregular and indefinite for determination. The selection of homes and hiding places by wild animals and birds on extinct but never, so far as I have observed in this and in South American volcanic countries, on inactive hot top nor on active volcanoes.

(2) Since this paper was written, Nov. 1890, there has been found (Feb'y 10, 1891), the *dust and small disentegrating parts of several cranium bones and three or four teeth of some human being*, in an urn of oblate oval form made of volcanic, iron-colored clays and sand and burned. The dimensions of the urn are: depth 68 c. m., greatest diameter 68 c. m., diameter across opening at one end 43 c. m., thickness in walls ¼ to ⅜ of an inch. This was discovered in a quarry in southern part of the city of Managua, about 15 feet below the earth's surface and resting on a stratum composed of volcanic ejecta hardened sufficiently to be quarried and used in the construction or all kinds of walls for residences and public buildings in the city of Managua; about sixteen feet beneath the urn, four hard conglomerate strata intervening, is the stratum on which human footprints were found in large numbers. The bones and urn were purchased by the consul for Austria, and will be sent to the museum in Vienna, Austria.

surface and strata in other countries, whose geology is better known, in order to determine the epoch when these people lived, and possibly to decide on the cause of their flight.

For a few feet south from the water margin of the lake, the formation is a coarse sandy beach, then an abrupt cliff 8 to 12 feet high above the surface of the water, thence south and south-eastward for more than a mile, the surface ascends to about 180 feet above the level of the water in the lake, then commences a series of volcanic montecules, cones, craters, and cerros, somewhat degraded by erosion, extending 25 to thirty miles eastward to lake Nicaragua.

The stratum bearing impressions of human feet is near lake Managua, about fourteen feet beneath the surface of the soil, and on a level with the high water mark. It is not much inclined but nearly horizontal with the present surface of the earth as it ascends south and east from the lake.

The mineralogical composition of the stratá from at least twenty feet below the stratum retaining footprints of man and *other mammals*, up to the surface of the soil is about the same. The larger proportion of more acid minerals are near the soil, the general composition of all are rhyoiite, trachyte, lipardite, phonolite, pumice, basalt, dolerite, audesite and black, also light colored, scoriæ, all in particles (large grains or small fragments) and bodies, mixed by water with volcanic ashes (and ores of iron) into a conglomerate whose contained grains and fragments are weakly cemented by the ashes and oxides into strata varying from six inches to four feet thick and consolidated to a hardness when in place, of from 2 to 2½ (excepting the upper stratum which has not yet hardened sufficiently to be separable, from top to bottom, into blocks), containing four or more cubic feet; exposed to a dry atmosphere these rocks soon harden to 3.25 to 4. Each stratum is separated from the one above it and, also the one below it, by a fine grained, *loose* sand, colored light brown by iron oxides and varying in thickness from 2½ to 4 inches.

Stratigraphically, the deposits, from at least ten feet below the stratum impressed by human feet, up to the surface of the earth, are:

(a) Superficial, 4 to 10 feet thick uncompacted or partly hardened ejecta conglomerate (3) containing numerous patches or small areas of

(3) Ejecta conglomerate in distinction from fused volcanic conglomerates and "shingle" and from "conglomerate" as defined by Lyell, Dana, Lo Conte, Prestwich

small fragments of pumice, also of colored clays and sands which when mixed with lime (CaO_2H_2) is used as a hydraulic cement which developes nearly as much tensile, torosile and adhesive strength as Roman cement; this is an acid conglomerate of grains and small fragments of volcanic materials the majority of which represent the early and middle part of the ashes-and-cinder-eruption in some period of explosive volcanic activity.

(b) A stratum of fine sand, 4 to 4½ inches thick, loose, uncompacted, slightly colored, light orange brown by hydrous oxides of iron.

(c) A stratum 2 to 2½ hard, of ejecta conglomerate, 4 to 4½ feet thick, coarse grains and small fragments well mixed, of a dark grey color spotted with hard black fragments of metamorphosed hornblende.

(d) A stratum of fine sand, uncompacted, resembling (b) in color, 2½ to 3 inches thick.

(e) A stratum of the same composition, hardness and color as (c) above described, 2½ to 3 feet thick.

(f) A stratum of fine, loose sand, 2 to 3 inches thick of a light orange color.

(g) A stratum 2 to 2½ feet thick of the same composition and color as (c) and (e) above described but harder, nearly 3 hard.

(h) A stratum of fine, uncompacted sand, 1½ to 2 inches thick, light, reddish brown color.

(i) A stratum composed of the same kind of materials and of the same color as (c) and (e), and about as hard as (g) above described, bearing intaglioes in the upper surface of numerous deep impressions of the feet of man and domestic animals, also containing, sunken until nearly covered, in its surface a few roughly polished stone implements, arrow heads, etc.

(j) A stratum of fine sand, uncompacted, the interspaces filled with water two and a half to three inches thick (4); it is colored light reddish brown by iron oxides, and has changed position and associates more than once since the Miocene period of the Cenozoic era.

(k) A deposit, below the usual level of the water in lake Managua, more than ten feet thick, of unknown thickness (I excavated only about ten feet, into this stratum when the water came in so rapidly as to cause work to cease), but, probably it is several hundred feet thick, *uncompacted* materials of the same composition as the harder strata above it; the water appears to have prevented the hardening of this deposit of volcanic ejecta conglomerate.

The different strata of sand in the above described. were deposits from the ordinary currents of water after the usual rains;

---

and other authorities, in being composed of grains, particles and fragments of rocks of irregular shapes, and pieces of minerals from the size of a MM. diameter to diameters of several CM., all ejected from volcanoes, and some particles softened afterward by meteoric influences, then transported from the sides of volcanic masses and the valleys between them, as floods of mud and deposited stratigraphically.

(4) This stratum has, strangely, been mistaken for "Miocene-period sand," and so published in Europe; it figured prominently in an article published in the Proceedings of the Victoria Institute, London, 1887, declaring the existence of man, these footprints, in Nicaraugua in the Miocene period. See Proc. Victoria Institute 1886 or 1887.

they are too thoroughly sorted or separated according to their densities to be ashes immediately from volcanoes falling on the hardening stratum of rock.

The strata of hardened volcanic conglomerate ejecta were deposited, each stratum most probably from large deep floods of mud brought down in continuous flow during one season, by torrents after long continued heavy rains, from the adjacent montecules, cones and cerros of materials erupted from volcanoes. The superficial deposit (four to twelve feet deep, uncompacted) was formed by several small floods of mud, occuring at intervals of several years. That these floods of mud occurred and that they were so thick in this locality is confirmed by vivid descriptions by some of the most eminent, educated and reliable citizens in Nicaragua who describe a similar occurrence on October 4, 1876. In this locality the city of Managua, the local name of these torrential floods of mud is "aluvions de barro;" this aluvion de barro filled the open houses, streets and plazas near the lake five and one-half feet deep with thick mushy mud composed of materials similar to those that are formed into hard conglomerate, hereinbefore described. Much of the slowly moving mud which remained in the city was washed into the lake by subsequent rains, but large masses were left in protected places, which have dried and hardened into isolated areas about twenty-four inches thick. Some of its upper surface, probably was washed away by rains because when these isolated parts, now hard and 24 inches thick, were prevented from flowing further, they were fully five and one-half feet deep, slowly flowing masses of thick mud. Several large boulders, some of them fully twelve tons in weight, were moved from depressions or concavities on the mountain's side, about one mile to the south of the city, where they had hardened. They were not hard enough to have been rolled even for 100 yards without breaking into fragments, but were deposited in the streets of Managua. A canal that once extended for two miles from east to west, and was forty feet wide and ten feet deep, was filled up by the mud flood, October 4, 1876, and is now one of the principal thoroughfares for traffic. At this date natural forces were acting on a grand scale, in this locality, changing the position of large quantities of material, yet the forces were small in comparison with that enormous flood of mud, which transported from the adjacent monticules and

cones sufficient loose fragmentary material (which had, long previously probably, been erupted from volcanoes) to their present position, where dry and hard the stratum (c) is now four and one-half feet thick.

The people whose footprints are found so numerous on stratum (i) must have removed from that locality before the occurrence of the "aluvion de barro" which formed the now hard stratum (g), because that flood of mud must have been over fifteen feet deep.

These strata dried slowly in a moist atmosphere; they are not fissured, consequently they did not dry rapidly; they show no indications of having been schisted, nor have any cracks afterwards been filled up by washed materials.

The time when men, dogs and horses* fled to Managua to shelter themselves from the highly heated cinders and ashes ejected from volcano Masaya, was most probably very long ago.

We may go back, in time, toward that epoch guided by such facts as the following. From intelligent and reliable witnesses we learn that volcano Masaya, about ten miles eastward from the city of Managua and on the west side of the city of Masaya, commenced on the 10th of November, 1858, emiting (from a fissure in its side about four hundred feet below the rim of its crater containing a lake of water) aqueous vapors, sulphurous acid gas, chlorine gas, carbon dioxide, etc. This continued for about ten days† then ceased, and, although a part of that fissure still exists, gapping and ugly, yet the entire volcanic mass is now so cool that its sides and the outer and inner edges of its crater are covered with small green trees and flowering plants, accompanied by many birds (5) which appear to consider that volcano extinct.

From history we learn that on the 10th of March, 1762, a fissure opened in the side of this volcano Masaya about three hundred feet below the rim of the crater, and poured out lava, at intervals, for several days, which covered an area about one-half

---

*No impression of the side toes of horses have been found in this stratum (i), in the two or three inch deep impressions of horses' feet.

†The statements are various.

(5) I here noticed in the volcanic part of Nicaragua and in other countries, that birds seldom or never visit volcanoes that have hot tops and have no isogeothermal plane corresponding with the surrounding country; birds and wild animals appear tc have an instinctive knowledge of the natural causes, dynamic and kinetic, at work in the mysterous depths of the earth.

mile wide, near the fissure, and widening gradually, for an extent of three or four miles into a forest of large exogenous trees, leaving over its course a mass of scoriæ, obsidian, vesicular lava and stones, which now look as if fresh and hot. Many trees along the edge of this flow of lava were carbonized, and parts of them are yet standing. The ashes and cinders then sent out with explosive force through the fissure, have been washed away down into the lakes. The volcanic activity created no great disturbance in the present city of Masaya, situated on the side of the volcanic mountain, opposite to the fissure, and the ashes reached to the city of Managua ten miles distant, only by occasional gusts of wind, not of sufficient quantity or temperature to cause any other unpleasantness than great apprehension of danger.

Anterior to this activity in 1762 we have no reliable human record of any other outburst from this volcano, and physical evidences indicate that it had been quiet for very many centuries, possibly for one or more geological epochs.

In comparing these facts in reference to the eruptions with other volcanoes the history of which is better known, but which have far more deeply eroded sides, of which facts are obtained, we find, that the materials forming, in considerably large part, the montecules, cones and sides of Etna, are easily loosened by rains and can be washed down in large quantities by torrents as at volcano Masaya; also that each, in its own locality, has seasons of heavy rains; but the lava which poured from Etna four hundred years B. C., and stopped the Carthagenian army in its march against Syracuse, is now, much of it, exposed on the earth's surface where it flowed and is not covered by sedimentary materials, washed down, from Etna's side, nor covered by floods of mud. Yet, in less than ten miles from volcano Masaya, the stratification near lake Managua of materials ejected from volcanoes and washed down and deposited, is hard and more than twelve feet thick at its least depth, above the hard stratum deeply impressed by human footprints, and these impressions of feet were made when the surface of that stratum was only partly hardened or in a stiff, muddy condition. Any estimate in years of thetime necessary toform and then to harden an ejecta conglomerate so slowly as not to fissure, such as each of these strata near lake Managua, and the time intervening between the drying and

hardening of one stratum before commencing the deposition of another, would be solely speculative. I have not sufficient data from my own or others' observations of volcanoes as to the average quantity of matter annually washed down from their sides, either by ordinary rains or during seasons of extraordinary floods, to make from the annual erosion an estimate of time necessary to form such deposits as the conglomerate strata beneath the city of Managua and extending toward the extinct volcano Masaya.

There certainly has been an epoch of great elevation and glaciation in part of Nicaragua, and a subsequent epoch of subsidence in all, and much ice melting and torrential floods in parts. There are many evidences here of the occurrence of the Glacial, Champlain and Terrace epochs. Probably this stratum containing human footprints, and the superimposed strata, were deposited during the later elevation and depression of the Champlain epoch and early part of the Terrace epoch; if so, then there is in Nicaragua evidence of men in large numbers and congregated in large towns or cities of thirty thousand or more, during the later Champlain or early Terrace epoch. And, if we accept M. Foret's calculations in reference to the time occupied in silting parts of lake Geneva by the river Rhone in an effort to get at the date of the conclusion of the glacial period there, as a basis for the hardening of the stratum underneath the city of Managua, we can probably say more than fifty thousand years ago.

Managua, Nicaragua, Nov. 10, 1890.

THE POST-ARCHÆAN AGE OF THE WHITE LIMESTONES OF SUSSEX CO., N. J.*

A REPLY TO A REVIEW†

FRANK L. NASON, Jefferson City, Mo.

In the review of the above paper the writer feels that Prof. Dana has laid undue stress upon some of the evidence adduced in support of his views and not enough on other.

It does not seem to be logical to assume, because a limestone contains chondrodite, magnetite and the oxides and silicates of zinc, together with intruded granite, that no amount of evidence

*Ann. Rep. State Geologist of N. J., 1890.

†Notice of Ann. Rep. State Geologist of N. J., 1890, July Number of Am. Jour. Sci., 1891; J. D. D.

will prove these limestones to be a locally metamorphosed fossiliferous limestone.

In other words, if positive and direct evidence can be found showing a transition from blue to white limestone, the fact that the white limestone has the above concomitants does not militate against the proposition in the least. The problem simply assumes another and a totally different phase. Instead of a question of geological age it becomes a study in metamorphism.

In the following paper the writer wishes to present, as concisely as possible, the evidence which led him to the conclusion that the white limestone of Sussex county is but the metamorphosed form of the fossiliferous blue limestone.

The evidence can be summed up under these heads:

1st. The topographic features of the two rocks.

This will include, (a) the nature of the dips and the foldings of the rocks; (b) the axes of special disturbance.

2d. The associated rocks.

This will include, (a) the accompanying bedded rocks, (b) the eruptive rocks.

3d. The transition of one limestone into the other.

This will include, (a) breccias in the white limestone, (b) breccias in the blue limestone, (c) graphite and fossils, (d) the actual tracing *across* the strike and *along* the strike from white to blue, this occurring in long lines, (e) occurs in many localities, (f) the breccias form the boundary lines.

1. Topographical features.

The white and the blue limestones are intimately associated with each other. Large areas of white limestone are never widely separated from the blue, and not a single outcrop of white limestone is known by the writer wholly independent of the blue.

(a.) In former reports and papers on this subject, the distinctive feature of the white with respect to the blue, has been "the universal southeast dip" and the northwest dip of the blue. Neither of these statements is in accordance with facts. It is usually difficult to observe the dip of the white limestone on account of the extreme metamorphism. Yet the fact that the white limestones do dip northwest is plainly to be observed. It frequently happens that one end of the slope of a hill is white limestone and the opposite end of the slope of the hill is blue. But whatever the direction of the dip, they both dip in the same direction. The

argument from southeast dip is farther shown to be worthless from the fact that the white limestones are proved anticlines in structure as well as the blue.

(b.) The white limestones occupy axes of great disturbance as denoted by the intrusion of eruptive rocks; by excessive shattering; by sudden and great disturbance of dip and strike.

The force of this point will be more strongly felt if one observes the *isolated* patches of white limestone between Franklin Furnace and Andover. Here the blue limestones lie against the gneiss with numerous outcrops of sandstone. When there is an area of white limestone, it is not far removed from the blue, but it is accompanied by great masses of granite and other eruptives and the sandstones are usually graphitic.

2. The associated rocks.

(a.) One of the strong ties which bind the two limestones together is the sandstone. This sandstone is found so abundantly and at such critical points as to form an evidence quite as strong as the actual passage of the blue into the white limestone.

These sandstones, in many places, form the axis of hills which are anticlinal in structure and which have one end of a flank blue limestone, and the other end white. These sandstones lie *under* the blue limestones and can be traced till they disappear *under* the white limestone.

These sandstones are graphitic when near either a white limestone or near a granite dike accompanied or unaccompanied by white limestone.

Prof. Dana is perfectly right when he says, "evidence drawn from graphite is of uncertain value," but that is a general statement. In the case at hand the writer believes that the *conditions* under which the graphite occurs make its testimony not only strongly corroborative, but direct and positive.

The presence of graphite in the blue limestone will be mentioned under 3. (b.) The white limestones, as already stated, are characterized by eruptive rocks. The most characteristic of these is the granite. There is hardly an area of white limestone which is not accompanied by granite; even where granite is not visible on the surface the white limestone is filled with intrusive sheets of it. This is proved by the drill borings, 1,100 feet deep at Franklin Furnace. There were eight holes in all, and each had successive layers of granite.

The blue limestones are almost wholly free from eruptives and granite is never present. Taking these facts in connection with the disturbed areas as shown by the topography, the presence of granite in the white limestone and its absence from the blue is as easily accounted for as the fact that the white limestone occupies areas of great disturbance, while the blue area is comparatively undisturbed.

3. The transition of the blue limestone into the white.

The writer regards this gradation as absolute proof of the synchronous horizon of these two limestones and that this fact alone is sufficient to establish the point at issue even were there no other confirmatory facts.

That this gradation or transition actually exists no one will doubt if once he visits the localities in question. (a) Breccias in the white limestone are not always readily observable, but localities are found where great masses of limestone are made up entirely of angular fragments. The interstitial matter is coarsely crystalline with scales of graphite. The angular fragments are bleached and some have a distinctly crystalline structure with scales of graphite and cloudy aggregations of the same mineral. In some, the angular outline of the original fragment is plainly observable, but near the center the crystalline structure is lost and the core is a rounded, comparatively unchanged mass. Were it not for the abundance and variety of these breccias one might regard them as a kind of concretion.

(b.) The breccias in the blue limestones, like those in the white, are found near the boundary line, or are, rather, the actual boundary line; the white limestones being found on one side and the blue on the other. The breccias are filled interstitially with crystalline graphitic limestones. The fragments themselves, while as dark as the blue limestone, have occasional scales of graphite. The degree of alteration depends upon the size of the fragment. The boundary line between the blue and white, when they approach each other, is either brecciated rock or a line of easy gradation as noted under 3 (d). (c) The presence of graphite and fossils in the blue limestone and in the sandstone, standing as isolated facts, do, as Prof. Dana says, have but doubtful significance, but this particular case stands as follows:—The fossils show these rocks to be among the oldest of fosiliferous rocks and thus more liable to metamorphic action; the

presence of graphite in the rocks and actually replacing these fossils shows that metamorphic action has actually operated to some extent; and the invariable proximity of these blue limestones and the sandstones *when graphitic* to either white limestone or granite is exceedingly strong evidence in support of the proposition that the metamorphism which changed the white limestone operated in a less degree, but at the same time, on the blue limestone and the sandstone.

(d) The actual gradation from white to blue across and along the line of strike. In the case in hand there is no possibility of mistaking super-position of a younger blue limestone on the white. The actual facts are that going from west to east there is encountered, first a coarsely crystalline white, graphitic limestone; last a blue limestone, plainly bedded and jointed. Between these two points, no more than fifty feet apart, these limestones shade into each other in color, in degree of crystallization, in the presence of graphite. That is, the graphite exists in every stage from the bright crystalline stage to cloud aggregations of carbonaceous matter which give the blue color to the blue limestone.

(e.) This gradation is not confined to a single locality, but the localities are numerous. In no locality is actual contact observed between white and blue limestone, but wherever exposure is of such a nature as to allow such contact to be observed, if it existed, the above facts are observed instead. The transition rocks are not taken from several localities and transition *inferred* from this series; but by going across a given exposure the complete series is seen and in place. No series of samples can give a perfect idea unless a continuous strip of rock were taken. Using the locality at Franklin Furnace as a point of departure, the localities at which this transition may be observed are as follows:—West of the Rudeville quarries four miles; on a hill east of McAfee, six miles; on the hills southwest of McAfee, numerous localities, five miles; on a small hill then north of McAfee, nine miles. These localities are all in the Vernon and the Wallkill valleys. In other localities near Oxford, Jury Jump mountain, and Andover, changes fully as convincing may be observed, and these point to the fact that the conclusions reached in the study of the Sussex county limestone may safely be extended to these also.

In conclusion it may be well to state that the two limestones are separated by one of two marked types of rock; either the band

of transition limestone or by a band of brecciated limestone rock; and that in no place does the limestone change from blue to white across a continuous exposure without one of these transition rocks.

NEW OBSERVATIONS ON THE GENUS TRINACROMERUM.

By F. W. Cragin, Colorado Springs, Colorado.

The type-skeleton of this genus, discovered in the summer of 1888, and partially described by the writer a few months later*, was nearly perfect when first seen by the workmen who found it, but was afterward broken in pieces by vandalic curiosity seekers, and had been scattered over portions of two counties before it came to the writer's knowledge. It was with great difficulty that the task of getting together such parts as had escaped utter destruction was accomplished, some of these being obtained by rock excavation at the original locality, others by dint of considerable perseverance in travel and moral suasion.

The expenditure of much time and labor in freeing the bone-fragments from the more or less silicified limestone matrix and in matching them, has resulted in restoring to a condition available for study, several parts which once seemed hopelessly incomplete. A study of the type, as thus renovated, and of parts of several other specimens, has enabled me to supplement my preliminary paper with the following descriptive notes.

The Skull.—Besides the very imperfect skull of the type (represented by the muzzle and a number of other fragments, of more or less importance), the writer has secured two skulls which belong—one† certainly, the other probably—to this genus. For convenience of reference, these three skulls may be designated respectively as A, B, and C.

As all preserved parts of the skeletal structure of *Trinacromerum* will be fully treated in an illustrated memoir, which is in preparation, a detailed consideration of the skull will not now be undertaken; but a few of its more conspicuous features may here be noted. The skull is very large (B, C) and long (A, B),

---

*Preliminary Description of a New or Little Known Saurian from the Benton, of Kansas. American Geologist, December, 1888.

†This skull seems to have pertained to an individual of about the same size as the type, with which it agrees perfectly in several parts preserved in both specimens. I regard it as not only congeneric but also co-specific with the type.

rather broad posteriorly (B, C), and gradually contracting anteriorly (B) to the greatly produced, high, and narrow muzzle (A, B). The fronto-parietal region is but moderately elevated, and slopes either way from the obtuse median ridge (B, C). There is a rather large elliptical or narrow-ovate parietal foramen (B, C). The orbit is large and ovate (B) in outline. The mandible has a long symphysis (A, B), posterior to which the rami are quite straight till at and near the posterior end, where they curve inward (B). The teeth (A, B) resemble in form and sculpture that to which Leidy has given the name, *Piratosaurus*‡, but are smaller and less curved, and their striæform folds of enamel reach much nearer the summit and are lacking entirely on the antero-exterior segment (A, B).

THE PECTORAL ARCH.—The coracoids are divided into a stout, saddle-shaped, anterior segment, and a thin, scoop-shaped posterior segment by two broad foramina which are either confluent anteriorly across the symphysial axis or separated by only a narrow symphysial prolongation of the posterior segment. The anterior segment is thickened in the interglenoid axis as an opposed pair of deep, massive abutments whose symphysial faces are marked with broad pits for the attachment of a median cushion of cartilage. It is anteriorly produced in advance of the glenoid fossæ and is posteriorly limited by the abrupt recession of the inner coracoideal borders from the symphysial axis at the foot of the steep posterior slope of the abutments. The thus formed inner-posterior angle of either abutment presents a complex inwardly directed articulation difficult to describe, but which, viewed from the slightly concave dorsal side of the abutment, presents the appearance of two short processes, the posterior of which is pedicellate. The posterior segment of the coracoid is characterized, like the anterior, by a transverse thickening culminating at the symphysis, but shallower than that of the anterior segment. It crosses the anterior end of the segment. While this posterior segment, as a whole, is concave upward, the transverse thickening is concave below and convex upward, reversing the conditions which obtain in the thickening of the anterior segment. The pre-glenoidal processes of the coracoids are long and blade-like, but are so broken in the type-specimen as not to

‡Cret. Rept. of U. S.

show their full length and outline. But on the block of stone bearing skull C (and which bears vertebræ indistinguishable from those of *Trinacromerum*) there is a perfect pair of anterior coracoideal blades. These lie mostly posterior to the skull and are directed agreeably with it, but their anterior end rests upon the posterior parts of the dorsal surface of the parietals, the skull having been accidentally turned over. These blades are about a foot in length and rather more than half an inch thick along the straight inner margins, diminishing, except near the end, to a thin outer edge. They gradually diminish in breadth (to two and one-eighth inches each) in the proximal two-thirds of their length, beyond which they have moderate lateral expansion.

The distal parts of the ventral plates of both scapulo-precoracoids are likewise preserved on the parietals of skull C. They are flat expansions, somewhat broader than those of the distal ends of the anterior coracoideal blades, whose outer borders they meet on either side in a straight articulation two or three inches long, being thus held some five inches apart, instead of meeting in the mid-line as do those of *Cimoliosaurus*. This articulation includes nearly the posterior half of the obtuse-angled extremity of the scapulo-precoracoid, the remainder of the extremity forming (as preserved) a free antero-exteriorly directed border which is squared like those of the articulation, and which may, therefore, have joined an omosternum placed anterior to the coracoideal blades.

The stout, extero-posteriorly directed end of the left *scapulo-precoracoid* remains, in the type specimen, in natural relation to the coracoid, which it joins to form the glenoid fossa.

A large and elongated fragment of the middle part of the former bone presents three faces: one concave, the others representing the outer aspect of the ventral and dorsal (precoracoid and scapular) plates, nearly flat and making a rounded angle of about 100° with each other.

THE PELVIC ARCH.—Of this, there are preserved in the type-skeleton the perfect right and imperfect left ilium, the greater part of the right pubis, the acetabular extremities and necks of both ischia, and part of the right ischial blade. On the right side, the union of the ischium and pubis, and on the left, that of the ischium and ilium remain undisturbed. The ilium is a clavate bone, rudely elliptical in cross-section of the shaft, and having the much enlarged lower end bent inward and forward.

The general outline of the pubis and ischium is much like that in *Plesiosaurus* as figured by Huxley*, though its details differ. The blade of the pubis is a warped plate, presenting, when viewed from above, two concavities separated by an antero-posterior axis of convexity, the major convexity embracing a large part of the middle and inner anterior regions, the minor occupying a small outer-anterior part.

But the pelvic arch possesses one feature that distinguishes it from any described sauropterygian pelvis with which the writer is acquainted†. The ilium does not articulate with, nor even closely approach, the pubis, being separated from it by the acetabular portion of the ischium, of whose acetabular face its own forms a posterior continuation. Thus the three elements of the acetabulum are brought into line.

THE VERTEBRÆ.—To what has been published concerning the vertebræ, there is but little that need be added here. As would be inferred from the great size of the skull, the anterior cervical vertebræ are not greatly reduced in size. The atlas and axis and their intercentrum are anchylosed, but their sutures persist. The cervical ribs are suturally adnate to the centra by single facets.

ON THE CONFOUNDING OF *NASSA TRIVITTATA* SAY AND *NASSA PERALTA* (CON. SP.)

By GILBERT D. HARRIS, Washington, D. C.

Nassa trivittata, a recent species inhabiting the eastern coast of the United States, was described in the second volume of the Journal of the Philadelphia Academy of Natural Sciences, in 1822, by Thomas Say.**

Eight years later, a somewhat similar though very distinct form obtained from the "Upper Marine" (Miocene) formation in the vicinity of St. Mary's River, Md., was inadvertently referred by Conrad to "*Nassa Trivittata*, Say."†† Morton repeated this error on page 2 of the Appendix to his Synopsis of the Organic Remains of the Cretaceous Group, published in 1834. The species is again referred to by Conrad in 1842 under the name "*Buccinum trivitta-*

*Vertebrate Anatomy, p. 182.
†In *Elasmosaurus*, the ilium is described by Cope as articulating with the *pubis* only. Extinct Reptilia, Batrachia and Aves of North America, p. 52.
**Op. cit. 1822, p. 231.
††Ibid., VI., 1830, p. 211.

tum, Say."* Tuomey and Holmes' use of this designation fifteen years later in their Pliocene Fossils of South Carolina seems correct insomuch as both the description and the figure they give indicate a species identical with Say's *N. trivittata*.§

In his catalogue of the Miocene Shells of the Atlantic Slope, Conrad questions the identity of the Miocene "*Tritia* (*Nassa*) *trivittata*" with the specimens referred to by Say, Tuomey and Holmes.‖

The following reference occurs in Meek's Checklist of Miocene Invertebrates, published in 1864:¶

"683. *Tritia trivittata* (Say?) Conrad. Md.; Va.; S. Car." The Maryland and South Carolina forms are here confused and considered identical. The specimens in the collection of the U. S. National Museum, from St. Mary's river bear the name "*Tritia trivittatum*, Say" in Meek's hand-writing; the identification is moreover initialed by Heilprin.

In 1867, Conrad described a new species under the name of *Ptychosalpinx* (*Tritiara*) *peralta*.** Although no locality is given for this species, the description, the figure, and the facts that it is a Miocene form and is, according to Conrad, the equivalent of *Tritia trivittata* Conrad (not Say) leave little room for doubting that the species here described is that occurring so abundantly in the vicinity of St. Mary's river, Maryland.

Heilprin has overlooked this name altogether in his Tertiary Geology of the United States, published in 1884, and continues to refer this Miocene form to *Nassa trivittata* Say.†† He uses the same designation in his list of Miocene species of New Jersey, published in the Proceedings of the Philadelphia Academy of Natural Sciences, 1887,† but whether in this case *Ptychosalpinx* (*Tritiara*) *peralta* (more properly *Nassa peralta*) or *Nassa trivittatoides* Whitf'd (MS.) is referred to, one cannot decide without seeing the specimens themselves.

Professor Clark of Johns Hopkins University has also overlooked Conrad's *N. peralta*, for, in 1888,‡ and again in 1891 he refers this form to *Nassa trivittata* of Say.§

The foregoing facts may be thus summarized:—

---

*2d Bull. Proc. Nat. Inst., 1842. p. 186. ‖Proc. Phila.Ac. Nat. Sci. 1862, p. 562.
§Op. cit. P. 135, pl. 28, fig. 4. ††Op. cit pp. 58 & 61.
¶Smithsn. Mi-cl. Coll. No. 183. p. 20. 19, fig. 5.
**Amer. Jour. Conch., iii, p 264, pl. †Op. cit. pp. 398, 401.
‡J. H. Univ. cir. vii. p. 66. §Ibid., x. p. 107.

Nassa tricittata Say, Jour. Phila. Ac. Nat. Sci., (1) ii, 1822, p. 231.
" " Conrad, Ibid, vi, 1830, p. 211 .... =*Nassa peralta.*
" " Mort., Synop. Org. Rem. Cret. Gp., 1834, App., p. 2......
.... =*Nassa peralta.*
Buccinum tricittatum Con., 2d Bull. Proc. Nat. Inst., 1842, p. 186......
.... *Nassa peralta.*
" " T. & H., Plioc. Foss. S. C., 1857, p. 135 *N. tricittata*
Tritia (Nassa) tricittata ? Con., Proc. Ph. A. N. S., 1862, p. 562 .....
.... { *Nassa peralta &* *N. tricittata.* }
Tritia tricittata Meek Check List 1864, p. 20........ { *Nassa peralta &* *N. tricittata.* }
Ptychosalpinx (Tritiaria) peralta Con. Am. Jr. Con, 1867, p. 264, pl. 19, fig. 5.
Nassa tricittata Heilp., Tert. Geol., 1884, pp. { 58, 61 ....*Nassa peralta &* / 54 ....*N. tricittata* }
" " " Proc. Phila., A. N. S., 1887 pp. 398, 401.... .
.... ?*N. tricittatoides.*
Nassa (Tritiaria) tricittata Clark, J. H. Univ. Cir., 1888, p. 66 =*N. peralta.*
Nassa tricittata Clark, Ibid., 1891, p. 107.................. *N peralta.*

Washington, D. C., August, 1891.

EDITORIAL COMMENT.

Diminution of Natural Gas.

Prof. J. P. Lesley has contributed a paper of much interest and value to the proceedings of the American Philosophical Society on the Grapeville gas wells. From it we condense the following:

A table showing the futility of all attempts to pipe natural gas to any great distance is a sufficient answer to the hopeful tone so often assumed in regard to its conveyance to towns far from the wells. It shows the initial pressure, size of pipe and loss by friction in conveying gas from the powerful gusher at Grapeville to the Cambria Iron Works at Johnstown, Pa.

Distance from well.	Size of pipe.	1886 Nov. 13	1887 Mar. 15	Loss.
0	10	200 lbs.	333 lbs.	—
4	"	182 "	320 "	13
8	"	170 "	295 "	25
12	"	148 "	261 "	34
16	"	129 "	212 "	49
20	"	100 "	168 "	44
24	12	85 "	130 "	38
28	"	70 "	95 "	35
32	16	58 "	76 "	19
36	"	51 "	37 "	39
40	20	——	25 "	12

The diminution of pressure in 40 miles from 200 lbs. and 333

lbs. respectively to 25 lbs. at the works sufficiently proves the impossibility of successfully conveying the gas in pipes to any great distance, at the same time the striking irregularity in the rate of diminution precludes the hope of discovering any rule, and raises the suspicion of considerable error of observation.

Another interesting fact illustrated in the same paper is the steadily diminishing pressure at the wells, foreboding ultimate failures at no distant date, a fact on which the GEOLOGIST has repeatedly insisted. The following table extracted and condensed from the same source establishes the assertion. The pressures are those attained by the wells after they have been closed for one minute.

GRAPEVILLE—TABLE OF MINUTE PRESSURES.

Well.	Depth. feet.	At first.	April, 1889.	Dec., 1889.	May., 1890.	Nov., 1890.	Dec., 1890.	Jan., 1891.	Feb., 1891.
Klingensmith	1100	460	390	250	180	100	95	75	65
Henry	1133	460	380	260	170	105	100	75	70
Moon	1149	460	390	260	175	100	95	75	65
Menosinger	1466	410	390	240	170	95	85	55	40
Kipple	1360	260	260	260	165	100	95	75	65
Byers	1350	125	—	—	—	—	—	—	60
Agnew	1420	75	—	—	—	—	—	65	65

This loss of pressure and consequently of gas in less than two years, points unmistakably to one conclusion—the disappearance of high pressure gas before long and the sinking of the great gushers to low pressure wells. They will then probably be very durable and the rate of diminution will itself diminish. Though useless for manufacturing purposes, they may still be very valuable sources of gas for domestic consumption. At the same time it is quite possible that even this hope may be disappointed and that the pressure will run so low as to yield practically nothing. This is indicated by the fact that the rate of diminution is at present nearly constant as is shown by the following table:

RATE OF DIMINUTION OF PRESSURE PER DAY.*

From April 29, 1889	646 days	321 lbs.	0.5 lbs. per day
" Dec. 16, 1889	413 "	188 "	0.455 "
" May 26, 1890	252 "	107 "	0.4 "
" Nov. 3, 1890	91 "	36 "	0.4 "
" Dec. 1, 1890	63 "	30 "	0.48 "
" Jan. 5, 1891	28 "	7 "	0.25 "

Professor L. points out that this falling off indicates that the gas

* In borrowing this table we have taken the liberty of correcting a slight mistake in Prof. Lesley's calculation by which he had brought out the diminution much too high. The last figures may be doubtful.

issues under the force of its own expansion and not by hydrostatic pressure. If this is really the case, we must, as said above, anticipate a steady falling off in the rate of diminution until it becomes practically constant and the well becomes a low-pressure source of gas.

The following deductions are of great economic importance:

"The steady decline in pressure from 390-380 lbs. on April 20, 1889 to 65 lbs. on February 2, 1891, predicts a speedy extinction of the use of natural gas at the Cambria Iron Works."

"'One of the wells at Grapeville was recently deepened to reach the 'Gordon Sand' and a small quantity was found, but not enough to warrant any hopefulness of its maintaining the supply. A part of the works at Johnstown are yet supplied with natural gas from Grapeville, but it is weakening so fast that we supplement it with artificial gases.'" Feb. 26, 1891.

Again:

"At the Cambria Works we are using the Archer oil gas to take the place of the natural gas and find this a very good substitute. The Archer process consists in vaporizing oil and mixing steam at a very high heat with the oil. We have also opened our mines again and are using coal in a great many sections of the works." March 13, 1891.

Supposed Trenton Fossil Fish.

During the past few months several notices have appeared of a discovery of fish fossils in lower Silurian (Ordovician) rocks in Colorado. At the recent meeting of the American Geological Society, Mr. Walcott, of the U. S. Geological Survey, exhibited some of these, and gave a few notes on the mode of their occurrence. They are found in a red sandstone, more or less mottled with white, and in a calcareous layer of similar color near Canon City, and were first collected by Mr. Stanton two or three years ago. They consist of a few entire plates and innumerable fragments, mostly white or reddish; and of long and apparently articulated columns reminding the observer of crinoidal stems. They are referred by Mr. Walcott to various kinds of fish and he has named several of them in accordance with this view. Thus one of them has received the designation of *Holoptychius? americanus* (preoccupied by Leidy many years ago), another that of *Asterolepis? desiderata*, while a third is styled *Palæchimæra prisca*.

These statements are of course surprising to the palæontologist.

though he is fully prepared to see the earliest vertebrate life carried downward through the palæozoic rocks far beyond where it is now known. But each step in the progress must be taken only after the most careful and thorough investigation and on the most satisfactory evidence.

In regard to the stratigraphy. Mr. Walcott has apparently examined the locality with great care, and has accumulated a large mass of evidence. Assuming the correctness of his observations there appears to be little room for doubting his conclusions. No ground exists for suspecting an overthrow or inversion of the strata, and some of the fossils as named by Mr. Walcott, though not exhibited, are of undoubted Ordovician (lower Silurian) age. Such fossils, according to the author, are found both above and below the beds containing the supposed fish remains. It is not easy therefore, on the assumption of these facts, to impugn the accuracy of the stratigraphical conclusions.*

But in regard to the palæontology the evidence is less satisfactory. There is no doubt that some of the specimens exceedingly resemble fish plates, as fish plates occur in the Catskill rocks. But it is not to Catskill species that a likeness would be expected, but to others more nearly approaching in date the epoch in question. Such species are those composing the genera *Pteraspis*, *Cyathaspis*, *Palæaspis*, *Diplaspis*, etc., and to these the fossils exhibited by Mr. Walcott bear not the slightest resemblance. The plates above mentioned certainly simulate the scutes or scales of certain Devonian and later fishes. But we may strongly insist on the deceptive nature of such merely external characters and ask for other evidence, before accepting the ichthyic nature of the fossils.

In this respect Mr. Walcott's paper was disappointing, inasmuch as it contained no proof of his proposition that these plates are the remains of fish. We must, however, await the appearance of his memoir before coming to a decision on the question. But it would have been more satisfactory to the palæ-ichthyologist had he learned at least the *nature* of the evidence.

---

*The palæontologist will feel some surprise at finding *Halysites catenulatus* mentioned among this fauna. Though this species has been reported from the Lower Helderberg (see p. 7 of the 2nd. Geol. Sur. of Pa.) yet its occurrence so low as the Trenton is scarcely less surprising than the presence of fish.

Mr Walcott's claim that his fossils though of Lower Silurian age yet resemble those of Upper Devonian strata, will doubtless be subjected to criticism, but the fact must be borne in mind that in several parts of the continent of Europe the fish are distinctly Devonian in type, though the molluscan fauna indicates *Upper* Silurian age. This combination is of course very different from finding similar fossils in *Lower* Silurian strata, but may serve in a slight degree to lessen the incongruity.

Microscopic examination was not reported. This lack is to be regretted inasmuch as such evidence is really of the first importance. We hope that it will be supplied later.

In addition to the plates already mentioned, Mr. Walcott exhibited certain crinoid-like objects which he believed to be notochordal or at least to indicate a spinal column. In our opinion, however, their appearance does not warrant such a reference, and the ichthyologist will feel grave doubts regarding the preservation of such objects from so low an horizon. Further examination will, we think, result in a change of opinion.

Man and the Mammoth.

Among the most interesting exhibits at the recent meeting of the International Geological Congress, was that of M. Max Lohest of Liège, Begium. Although unfortunately M. Lohest's paper was crowded out, and consequently the members had not the advantage of hearing it, yet his photographs and pamphlet were examined by several of those who combine archæology with geology.

M. Lohest's paper read before the Anthropological Congress gives an account of his investigation of the grotto of Spy, near Liège, on the property of the Count of Beauffort. In this cavern M. Lohest found under a thick bed of rubbish and fallen fragments of limestone, three distinct ossiferous beds. The uppermost of these was in part stalagmitic, and contained a few bones of an undetermined species of deer, a bear's tooth, and some pieces of the bones of the mammoth. Beside these and mingled with them were great numbers of flint implements of various patterns, some of them resembling the type known as "Mousterian," from the cavern of that name, and others are like those found in the well known Engis cave, in Belgium. Some are notched like saws and of very thin and delicate workmanship. They consist of scrapers, points, blades, knives, etc., worked on

one face, some apparently intended to be set in handles and others not.

No instruments of bone or of ivory were found in this upper layer and the flints are mostly covered with a white or bluish patina sometimes very thick.

Under this stalagmitic layer was a second ossiferous bed, usually red from the presence of iron ore, many fragments of which were found.

Here occurred the following fauna:

Rhinoceros tichorhinus,	**abundant.**
Equus caballus, (horse)	**very common.**
Sus scrofa (pig).	
Cervus elephus (red deer).	
" canadensis? (elk).	
" megaceros (Irish elk).	
" tarandus (reindeer).	
Ovis aries (sheep).	
Bos primigenius (bison).	
Bos priscus (aurochs).	
Elephus primigenius (mammoth)	**very abundant.**
Ursus spelæus (cave bear)	**scarce.**
Meles taxus (badger).	
Canis vulpes (fox).	
Canis lupus? (wolf) familaris? (dog).	
Mustela foina (weasel).	
Hyena spelæa (cave hyena)	**very abundant.**
Felis spelæa (cave lion)	**a few teeth.**
Felis catturs (cat).	

These determinations are due to M. Fraipont, professor of palæontology at the University of Liège.

Numerous hearths were also found on this layer composed of stones, and containing burnt wood and ashes.

The materials used by the old inhabitants of this grotto were flint, phthanite, sandstone, chalcedony, opal, ivory, bone and horn, and the total number of implements obtained was very large. There are 140 "mousterian" points, most of them thick at the base and not intended for setting in handles, whose average dimensions are 4 inches long by 3 inches wide; a number of fine flakes and awls, and arrows or dart heads, of very fine workmanship, and some of them 5 inches long, resembling in type the "solutrean" implements of the Dordogue, a single small core from which flakes have been taken, and numerous blocks rejected on

account of some defect after a flake or two had been struck off, and 300 scrapers of various sizes and types.

Implements etc., of ivory were more numerous in this layer than in any other known cave in Belgium. Chips were so abundant as to form a breccia in one place. The objects found were for the most part for dress or ornament, and the material had often degenerated into a chalky substance. Many of them were unfinished or the different stages of manufacture were revealed. Some of them were marked with striation as was also the case with the implements of horn and of bone found with the ivory. On a rib of the mammoth or rhinoceros was found a series of "circumflex accents" ranged one above another, of which a figure is given in the pamphlet. One hollow horn was filled and stained with iron oxide, and is supposed by M. Lohest to have been a receptacle of this material for coloring the persons or the implements of the cave men. These with four fragments of pottery, found by another investigator, complete the list of relics from the second ossiferous layer.

The third contains a fauna so far as it goes, identical with that of the second bed.

Rhinoceros tichorhinus,	abundant.
Equus caballus,	very abundant.
Cervus elephus,	rare.
Cervus tarandus,	very rare.
Bos primigenius,	common.
Elephus primigenius,	common.
Ursus spelæus,	rare.
Meles taxus,	rare.
Hyena spelæa,	abundant.

In this bed, however, were found as in the other, abundance of flint implements, but somewhat differing in form and material from those above mentioned. The great interest of this layer, and indeed of the whole find is the discovery not only of the works of man, but of man himself, in the form of two partial skeletons, one skull of which is nearly perfect. This of course forms the central point of M. Lohest's paper, and he justly goes into detail concerning it. We will condense his account written by Dr. Fraipont.

"The human relics belong to the most ancient fossil race, that of Neanderthal or of Canstadt. The skulls, fairly complete, present all the ethnic characters of that race, whose remains are known from France,

Italy, Austria, Germany and Sweden. Hitherto only a single jaw has been obtained from a cave (Naulette) in Belgium."

One of these skulls is apparently that of an old woman, the other that of a middle-aged man. They are both very thick. The former is clearly dolichocephalic (index 70), the other less so. Both have very prominent eyebrows and large orbits with low retreating foreheads, excessively so in the woman. The lower jaws are heavy, the older has almost no projecting chin. The teeth are large, and the last molar is as large as the others. These points are characteristic of an inferior and the oldest known race.

The bones indicate, like those of Neanderthal and Naulette, small square shouldered individuals."

M. Lohest adds:

"The skeletons from Spy are one of the most important discoveries relating to the oldest known race of men." "The cave shows three ossiferous layers, and remains of the mammoth occur in all three." "Stone implements chipped only on one face indicate the 'mousterian' type of industry."

"The relics of the three layers indicate an advance in the character of the workmanship."

"The second layer by its association of chipped tools with ornaments of ivory and bone shows its close relationship to the 'mousterian' type, and at the same time is free from all suspicion of accidental mixture."

"The study of the bones of the lowest level proves beyond doubt that the earliest race of men as yet known in Belgium, had a skull of the type of 'Neanderthal' and used instruments of the 'mousterian' pattern."

In the above discovery we have at last clear and indisputable traces of the men whom up to now we have known almost entirely by their tools. A few disjointed bones not free from suspicion, are now fortified by evidences that cannot be gainsaid, and the old Canstadt or Neanderthal race stands before us as an extinct but real ancestor.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Congrès Géologique International. Compte rendu de la 4*me* Session. London, 1891. This volume, which appeared in America but a few days before the opening of the fifth session of the international congress, consists of four parts and four appendixes. It has six geological maps and eighty figures; also a plate of five profiles through the crystalline schists of the western Alps. Part I. is a historical account of the Congress and its origin. Part II. embraces the daily record of the meetings of the Congress. Part III. the most important and valuable, embodies the actual new work which was transacted by the Session. Here are papers

on the crystalline schists by Hunt, Heim, Lory, Lehmann, Lévy, Lawson, Powell, Irving, Chamberlin, Van Hise, Becker, Dutton, Lossen, and Reusch, followed by synopsis of the discussion on the same by many of the attending geologists. Following these are miscellaneous discussions of the classification of the Cambrian-Silurian-Taconic, or primordial rocks of the world, and of the Tertiary and Quaternary. Part IV embraces extended papers on the geology of the different portions of the British islands by Hicks, Marr and Tiddeman, Strahan and Reid, Fox-Strangways and Lamplugh, and Reid, and shorter notes by Topley, Drew, Goodchild, Blake, Woodward and Winward—all grouped under the general title "Explication des Excursions." Appendix A consists of the report of the American Committee on classification and nomenclature, the reporters being Frazer, Winchell, Williams, Stevenson, Cook, Smith, Cope and Hitchcock. Appendix B is the report of the British sub-committees made to the third session of the Congress at Berlin in 1885, distributed at that time separately, but omitted from the Compte rendu of the session. It now appears as a "second edition," with an explanatory "review of the position" by T. McKenny Hughes, the separate reporters being Woodward, Reid, Gardner, Jukes-Browne, Topley, Huddleston, Blake, Irving, Morton, Strahan and Marr. Appendix C is the report of Prof. Dewalque, secretary of the international committee on unification of nomenclature, in which he says that no national committee, except that of the United States, had rendered any report to the general committee. He calls attention specially, and favorably, to the recommendation of the American committee respecting the nomenclature of the lower paleozoic, viz: *Taconic* for the primordial, *Cambrian* for the second fauna, and *Silurian* for the third fauna. At another time (in the discussion of the classification of the Cambrian-Silurian-Taconic, p. 227,) Prof. Dewalque commends the conclusions of the American committee in the following terms:

Les réunions précédentes du congrès et de la commission de nomenclature ont montré qu' une très-grande majorité de géologues est favorable à une division en trois parties; on constate le meme fait aujourd'hui. Pour ces parties on a proposé les noms Cambrien, Ordovicen et Silurien. L'orateur ne pent être consideré comme hostile à l'Ordovicen car il a eu l'honneur de le patronner dans la commission, qui l'a admis. Toutefois, dans son rapport pour le congrès de Berlin, il a cru devoir tenir compte des revendications produites en Amérique au sujet du Taconique de M. Emmons. Les controverses qui se sout produites depuis lors aux Etats-Unis auraient pu faire hesiter un géologue comme l'orateur, qui n' a jamais vu ce pays; mais la lecture du rapport du comité Américain suffit, à ses yeux, pour lever tous les doutes, et le nom de Taconique a pour lui la priorité et a droit à désigner la division inférieure. La division moyenne est le Cambrienne, la supérieure reste Silurienne. Cela contrariera quelques usages, mais cela a d'autres mérites sur lesquels l'orateur n'insiste pas.

L'honorable M. Walcott a combattu cette division, proposée par ses compatriotes; mais son argumentation ne parait pas irréfutable. L'orateur

admet volontiers que M. Walcott ait découvert une riche série de fossiles de la faune seconde sur certains points du territoire appelé Taconique, mais ce progrés dans nos connaissances ne pent avoir d'influence sur la question. Ce q'il faut savoir, c'est la position réelle du Taconique d'Emmons. Or, il semble incontestable que c'est une série à faune primordiale. Si ce nom doit être conservé, il ne pent être appliqué qu' à ce que l'on proposait d'appeler Cambrien. Il faut le conserver parce qu'il a la priorité. L'orateur ajoute volontiers qu' il sera charmé de voir rendre cet hommage à la géologie Americaine, laquelle nous a appris tant de choses sur le grand ensemble de couches dont nous cherchons la meilleure classification."

Appendix D contains lists of the members of the congress.

Mesozoic and Cenozoic formations of eastern Virginia and Maryland. By N. H. DARTON, U. S. Geological Survey. Bull., G. S. A., vol. ii, pp. 431-450, with a map and sections; April 14, 1891. The formations here described, successively separatad from each other by erosion intervals, are the Potomac, of late Jurassic or early Cretaceous age; the Severn, of later Cretaceous age, being the southern extension of the New Jersey greensand series; the Pamunkey, of Eocene age; the Chesapeake, belonging to the Miocene period; the Appomattox, referred provisionally to the Pliocene; and the Columbia, regarded as early Pleistocene. It is ascertained that the transverse depressions of the coastal plain region were first excavated during the interval between the Chesapeake and Appomattox formations; for the earlier members of the series bear no marks of transverse drainage. At a later date, the Appomattox and Columbia formations were separated by an epoch of great uplift and erosion. "This epoch," according to Mr. Darton's observations, "differed from its base-leveling predecessors by greater relative emergence and consequent stream-action which developed the greater part of the present physiography of the region. This erosion deepened and greatly widened the transverse drainage depressions, and trenched the side drainage depressions, cut into the edges of the terraces to an extent gradually increasing northward from North Carolina, and in northern Maryland resulting in the removal of wide areas of the coastal plain formations, especially he Chesapeake and Appomattox."

On the Triassic of Massachusetts. By BENJAMIN K. EMERSON. Bull., G. S. A., vol. ii, pp. 451-456, with a map; April 23, 1891. Marine currents probably produced by tides of the bay of Fundy type, are shown to have distributed arkose from south to north, derived from the granites and schists along the west side of the Triassic bay or estuary in Massachusetts; and on the east a strong ebb current spread a coarse conglomerate, transporting its materials from north to south. In more quiet water along the central part of the basin, sandstones and shells were deposited. An artesian boring at Northampton passes through the arkose to a depth of 3,000 feet. Professor Emerson finds evidence of monoclinal faulting with upthrows on the east side of the faults, like the structure discovered by Davis in the continuation of this basin in Connecticut.

Glacial grooves at the southern margin of the Drift. By P. MAX FOSHAY and RICHARD R. HICE, Bull., G. S. A., vol. ii, pp. 457-464, with a plate and one figure in the text; April 27, 1891. This interesting paper describes the terminal moraine, kames, terraces, potholes, and glaciated rock surfaces near the drift margin, in the valley of Beaver river, northwestern Pennsylvania. Powerful glacial erosion is shown two miles or more south of the terminal moraine mapped by Lewis and Wright, upon the area of "the fringe" of frequent boulders, which extends some miles in front of the moraine in this neighoohood.

Post-pleistocene subsidence versus glacial dams. By J. W. SPENCER. Bull., G. S. A., vol. ii, pp. 465-476, with a map; April 30, 1891. Shortly before the deposition of the glacial drift, there is shown to have been an elevation of the drift-bearing areas over 3,000 feet higher than now, and probably for a brief time to over 5,000 feet. Succeeding this uplift, the author believes that a subsidence of the land carried it so far beneath the sea level that the now raised beach lines partially surrounding the great lakes of the St. Lawrence were shores of the ocean. Recent emergence of the land, according to this view, is recorded by the succession of these beaches at different levels; and the alternative explanation which attributes the beaches to glacial lakes of fresh water dammed by a receding ice-sheet is disputed. A reprint of this paper, with slight changes appeared in the June number of the Geological Magazine.

On the Geology of Quebec and environs. By HENRY M. AMI, of the Geological survey of Canada. Bull. G. S. A., vol. ii, pp. 477-502, with seven sections; April 30, 1891. The intricate and much debated structure and relations of the Cambro-Silurian terranes of Quebec and its vicinity are here carefully discussed, with lists of the fossils collected in numerous localities by the author and others. Mr. Ami advocates the retention of the name Quebec group, and considers the group to comprise three natural and well-marked parts, lying next below the Trenton limestone in the following descending order: The Quebec, or upper division; the Lévis or middle division; and the Sillery or lower division. The rocks thus grouped are referred by Selwyn to the Hudson-Utica horizon above, instead of below, the Trenton.

Some New Species of Crinoids and Blastoids. By PROF. R. R. ROWLEY and SID. J. HARE. In *The Kansas City Scientist* for August 1891, we have what is practically a continuation of the paper on *Some New Species of Echinodermata* by the same authors in the same magazine for July. The present paper contains descriptions of twelve new species, all of which are illustrated by figures drawn by professor Rowley.

Advance sheets from the 17th Report of the Geological Survey of the State of Indiana, PROF. S. S. GORBY, State Geologist. *Palæontology.* By S. A. MILLER. Mr. Miller's contribution to the 17th Report of the Geological survey of Indiana, embraces 95 pages of text, and 20 plates with appropriate descriptions. 130 species of fossils are described, and of these 126 are new. The paper opens with remarks on the geologic formations

of Indiana. The lower part of the Niagara group, in Indiana, is characterized by the presence of the remains of cystideans; while the upper part abounds with crinoids, brachiopods, bryozoa and other fossils." Most of the cystideans belong to the very variable genus *Holocystites*. It is stated as a fact worthy of note that half of all the species of cystideans known from America occur in the Hudson River and Niagara groups of Indiana. There are remarks on the scientific value of fossils and on rules for nomenclature.

Of the fossils described there are three species of sponges, and from the head lines it would appear that Mr. Miller stands with Saville-Kent, in opposition to the views of a majority of competent zoologists, in referring sponges to the sub-kingdom Protozoa. There are twelve species of corals, one of which, the *Leptopora gorbyi*, n. s., is doubtfully referred to the Tabulata. Seventy-eight species belong to the *Echinodermata*, mostly cystideans and crinoids. Of the genus *Holocystites* alone there are fifteen species.

Among the echinodermata the following new genera are proposed:—*Stribalocystites*, *Zophocrinus and Blairocrinus*. Among sponges there is one new genus, *Cyclospongia*.

The remaining genera and species embrace a few species of brachiopoda, one Conularia and a number of mollusca. The *Pleurotomaria harii*, page 83, Plate XIV., Figs. 3 and 4, might properly and profitably have been compared with *P. carbonaria*, N. and P., and *P. newportensis* White.

Second Annual Report of the Geological Survey of Texas, 1890, E. T. Dumble, F. G. S. A. State Geologist. *Carboniferous Cephalopods*. By Alpheus Hyatt. The paper on Carboniferous cephalopods by professor Hyatt embraces pages 329 to 356 inclusive, in the Second Annual Report of the Geological Survey of Texas. The forms described were collected in part by the Geological Survey of Texas, part belong to the National Museum, and a few belong to private individuals whose names are given in connection with the specific descriptions. The genera represented are divided between the *Nautiloidea and Goniatitinæ*. To the first group belong *Temnocheilus*, represented by five species; *Metacoceras*, by five species; *Tainoceras*, one species; Domatoceras, a new genus to which is referred one species; *Asymtoceras*, one species; *Phacoceras*, one; *Ephippioceras*, one; and *Endolobus*, one. To the Goniatitinæ belongs the genus *Gastrioceras* which is represented by the new species *G. compressum*. As stated in the prefactory note the paper comprisesa larger number of species of Carboniferus cephalopods than had previously been got together in a single publication. Excellent outline figures accompany the descriptions.

In the Second Annual Report of the Geological Survey of Texas, page 552, professor W. F. Cummins describes a very beautiful and interesting little coral from the Carboniferous strata of Texas, under the name, *Hadrophyllum aplatus*. *H. aplatus* is certainly very closely related generically to *Microcyclus discus* Meek and Worthen, and it is possible that this last species will have to be referred to *Hadrophyllum*. Six good figures illustrate Prof. Cummins' species.

LIST OF RECENT PUBLICATIONS.

V. *Foreign Publications.*

Records of the Geological Survey of New South Wales, Vol. II, Part 8, contains: Notes on a Collection of Rocks and Minerals, from Mount Morgan, near Rockhampton, Queensland, collected by Mr. C. S. Wilkinson, by T. W. Edgeworth David, and William Anderson. With an introduction by C. S. Wilkinson. Laboratory Notes on some N. S. Wales Minerals, by J. C. H. Mingaye. On the Occurrence of Microscopic Fungi, allied to the Genus *Palæachlya* Duncan, in the Permo-Carboniferous Rocks of N. S. Wales and Queensland, with Plate VII, by R. Etheridge, Junr. The Associated Minerals and Volatility of Gold, by T. W. Edgeworth David, B. A. Analysis of Samples of Coal and Coke, manufactured from the various Coke-producing Coals in the Northern, Southern, and Western Coal Districts of N. S. Wales, by J. C. H. Mingaye. Note on Mr. J. C. H. Mingaye's Analysis of N. S. Wales Coals and Cokes, by T. W. Edgeworth David. *Lepidodendron australe* M'Coy—Its Synonyms and Range in Eastern Australia, by R. Etheridge, Junr.

Eclogæ geologicæ Helvetiæ, Vol. II, No. 4, contains: Revue geologeque suisse ponr 1890, Favre et Schardt; Programme des Excursions d'aout 1891 dans les Prealpes romandes, avec pl. 9-12.

Mittheil. d. Naturforsch. Gesell. in Bern, contains: Notizen über den Lias von Lyme Regis, J. B. Thiessing.

Annalen K. K. nat. Hofmuseums, Band VI, No. 2, contains: Meteoreisen-Studien, Cohen u. Weinschenk; Die Gasteropoden der Schichten von St. Cassian der südalpinen Trias, Kittl; Ueber Nephrit und Jadeitgegenstände aus Centralasien, Haberlandt.

Föld. Köz. (Budapest), Vol. XXI, Nos. 4 and 5, contains: Awaruit. ein nickeleisen-mineral, Szabo; Beitrage zur Foraminiferen-fauna der Alttertiären Schichten von Kis-Gyor, Kocsis.

CORRESPONDENCE.

THE SO-CALLED SAND-DUNES OF EAST HAMPTON, L. I.—In a letter received from Geo. R. Howells, of South Hampton, of date January 21, 1886, my attention was called to certain sand ridges at East Hampton, L. I. The writer said: "Were you aware, I wonder, of the existence of two sand dunes, like small amphitheaters in form, right along, or in the midst of the richest farm lands a mile from the present shore line—perhaps not quite a mile—in the outskirts of East Hampton? These are veritable sand dunes of white sand covered with a growth of ordinary beach grass, and a geological puzzle. If we could say they were deposited there by a cyclone, it would shorten matters, but we can't, and there is a difficulty in holding that they are signs of an old beach line. It is with me a standing puzzle."

The study of the drift phenomena, on the west end of the island led me to suspect that the sand dunes in question were formed by subglacial streams issuing from the front of the ice-sheet that stretched along the Atlantic border during the Ice Age. It was not until last July, however, that I had an opportunity of visiting the place in person, and it was gratifying to find my conjecture confirmed by actual observation. The sand dunes referred to are really kame formations. This can be seen at a glance by any one familiar with glacial phenomena. Similar formations occur along the whole extent of the south side of the Island; but in general they are not quite as well defined as those at East Hampton. The so-called sea beaches in front of our bays, as at Rockaway, Great South beach, etc., are the same in origin. This hardly seems possible, but the more this phenomenon is examined the more evident the fact becomes. There is a beautiful system about these beach or kame formations, and their study had led me to suspect, some years ago, that the system extended for miles beneath the waters of the sea, and it was very gratifying to find this view partially confirmed by Prof. Agassiz. In his Life and Correspondence, edited by his wife, page 448, in a letter to Elie DeBeaumont, he says: "Mr. Dezor recognized all the modifications of the osars of Scandinavia. The deposition of the osars, as seen here, is evidently due entirely to the action of the waves, and their frequency along the coast is a proof of this. In a late excursion with captain Davis, on board a government vessel, *I learned to understand the mode of formation of the submarine dikes bordering the coast at various distances, which would be osars were they elevated.*" The italics are our own, as the statement seems to confirm what I had conjectured, but I think Prof. Agassiz is in error in regard to their origin. Prof. G. F. Wright and others who have studied these kame-deltas along the southern front of the terminal moraine, in New England, as well as in Long Island, could see that these formations—osars—as Prof. Agassiz calls them, are not the result of wave action, but are due to subglacial currents issuing from the front of the glacier. At Montauk, for a distance of some twelve miles, the waves of the ocean break directly upon the base of the ridge or terminal moraine. At this point the whole south side of the Island has become submerged, and we can readily imagine what the floor of the ocean is like some distance from the present shore line. The sea is evidently gaining on the land along the whole extent of the Island, and it is only a question of time when the whole plain, south of the central ridge, will be washed away, unless something is done to check the inroads of the sea. If this invasion of old ocean has been going on for the past ten thousand years, the south side of the Island must have been at one time much more extensive. There is evidence to show that at South Hampton, two hundred years ago, the shore line was at least half a mile farther south. At the same rate of erosion four hundred years would bring the waters of the sea over the so-called sand dunes at East Hampton, and these osars or kame-deltas would become the submarine dikes referred to by Prof. Agassiz. It is true that the waves of the sea would somewhat modify the contour of the plain in

the process of submergence, but there is no doubt but that the same system of ups and downs would exist as now characterizes the south side of the Island.

There may be some other explanation found for the formation of the beaches at East Hampton, but as I stood on their summits and looked northward, the old lines of drainage from the moraine to the sea were plainly traceable, and I am very confident that they are glacial in origin.

The study is full of interest, as much so as the coral formations of tropical shores, as remarked by Prof. Shaler, and many problems connected with it remain to be solved. Future discoveries, I think will prove that oscillation has had little to do with the formation of either.

Eastport, L. I., August 9, 1891. JOHN BRYSON.

Viejo range of Nicaragua. I have just arrived here from an examination of the 18 mile long volcanic mass, *Viejo*—in front or north of this town—and found at a distance of about three leagues from the south base of its cones, fifty-six large springs of water issuing from fissures, all along the south side, at elevations of 40 to 80 feet above the Pacific ocean; also one spring of cool water flowing from a small clay-bottom basin, at an altitude of about 4,000 feet above the ocean, the highest cone, except one toward the west, which is 5,670 feet above the ocean.

On the north side of the cerro are several (8 or 10) large springs of tepid water, two of which contain so large a percentum of $CaCO_3$ as to have deposited hundreds of thousands of tons of calcareous tufas—nearly pure—6 to 18 inches thick. In many places in this tufa the lime has substituted organic matter in perfection so as to display the most delicate venation of leaves, molds of annelids and insects, the tissues of trees, etc. These springs on the north side of the volcanic mass, flow into a tide-water estuary which extends for about 70 miles eastwardly from the gulf of Fonseca and "heads" at several springs of hot water, at the N. E. base of the cerro, in a valley which extends for about 20 miles eastward to lake Managua. I have drafted the skeleton for a paper descriptive of this volcanic cerro. J. CRAWFORD.

Chichigalpa, Nicaragua, 27th June, 1891.

PERSONAL AND SCIENTIFIC NEWS.

THE KANSAS CITY SCIENTIST for July, 1891, has a paper describing *Some new species of Echinodermata*, by Prof. R. R. Rowley and Sid. J. Hare. A plate containing twenty figures drawn by Prof. Rowley accompanies the paper. Fifteen new species are described. The despairing palæontologist is disposed to ask how many more new species of crinoids the Subcarboniferous strata of the Mississippi valley are going to furnish!

THE UNIVERSITY OF IOWA has received from Prof. C. A. Whit-

ing, of the University of Deseret, a cast of a slab containing some undescribed footprints. The slab was first used as a door-step by a citizen of Salt Lake City. While serving "such base uses" it was discovered by Dr. John R. Park, president of the University of Deseret and secured for the University museum. The casts were made by Prof. Ward, of Rochester. The tracks are three inches long and about three inches wide. There is in each the impression of three stout, clumsy toes, behind which is the imprint of a thick, well developed pad. The impressions of the fore and hind feet do not coincide, nor do they overlap to any appreciable extent. The stride of the animal was about eighteen inches.

So far as learned from Prof. Whiting no description of the tracks has been published. The relations of the animal, and the geological horizon from which the slab was obtained have not been determined.

IN THE ANNALS AND MAGAZINE OF NATURAL HISTORY FOR JULY, 1891, Dr. P. Herbert Carpenter has a somewhat caustic review of S. A. Miller's *Description of some Lower Carboniferous Crinoids from Missouri*, published by the Geological Survey of Missouri, and Miller and Gurley's *Description of some new Genera and species of Echinodermata from the Coal Measures and Subcarboniferous Rocks of Indiana, Missouri, and Iowa*, published at Danville, Ill. The papers referred to contain descriptions of six new genera and over ninety new species of Crinoids. In summing up his review Dr. Carpenter expresses himself thus severely: "Three at least, and probably four, of his [S. A. Miller's] last six new genera of Crinoids would never have been proposed had he taken the trouble to make himself properly acquainted with the bibliography of his subject; and I suspect that quite half of his ninety new species will prove to be synonyms when they come to be revised.

Careless and ill-informed authors of this class are the terror of systematists in all branches of biology. Their sole object seems to be the association of their names with as many 'new species' as possible, and one's first impulse on seeing 'A Description of Some New Genera and Species,' etc., is to parody 'The Bogie Man,' and say with bated breath,

'Hush! Hush! Hush! Here comes the species man.'"

DR. J. KOST IN HIS PRELIMINARY SURVEY OF FLORIDA discovered in the channel of the Ichetucknee river, the remains of six mastodons, an elephant, one camel, and teeth of two species of rhinoceros, with many bones of animals still living, in a higher deposit. Two of the mastodon skeletons are nearly perfect. At Heidelberg University, Tiffin, O., the Polytechnic Department is engaged in making plaster of Paris restorations of these and of

all other extinct life types available, and will furnish them to institutions at not over one-fourth the cost of originals.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Of the many papers read in the geological section during the late meeting at Washington, not all can be specially noticed.

Dr. Foote, of Philadelphia, gave an account of the discovery of diamonds in a meteorite from Arizona. In slicing the meteorite something hard was struck that destroyed the corundum wheel, and was only cut with great trouble. On examination of the layers a nest of small black diamonds was discovered, and the mineral recognized by its intense hardness. A very small and clear crystal was also found, but was lost during the operation. This, said Dr. Foote, was the first example of the occurrence of diamonds in an iron meteorite, though it had been twice reported from stony ones in Russia.

Mr. Wm. Hallock related to the section the story of the deep boring now in progress at Wheeling. It was begun in the hope of finding gas or oil, but when the depth of 4,500 feet had been reached without any success, the projector determined to abandon it and an order was given to that effect. Prof. I. C. White, of Morgantown, W. Va., hearing of this order and realizing the importance of the opportunity, set off immediately for Wheeling, and obtained a countermand only just in time, as the contractor had already begun to draw the casing. He persuaded the owners to give up the well, which was entirely dry, for the purpose of scientific experiment. This they did and generously offered to contribute the amount needed to deepen the hole to 5,000 feet. The U. S. government then agreed to furnish a new cable, and as soon as this has been received the work will recommence.

According to experiments already made with the thermometer, apparently with all due precautions, the result is new and unexpected. A rate was obtained below the 100 foot plane of 1° in 90 feet, increasing downward till at the bottom it amounted to 1° in 60 feet. As this contradicts nearly all the data obtained elsewhere it is more probable that some local cause of error or some exceptional condition prevails at the well, at least in its upper part, for the lower figures do not differ much from those obtained elsewhere.

Prof. Lester F. Ward read two valuable papers on the plant life of the Trias and the correlation of strata by vegetable fossils. He showed that our knowledge of these organisms has been until lately, and is indeed even now to a less degree, too imperfect to allow of their use in the correlation of strata, but maintained that as the gaps in fossil botany are filled they will become available for the purpose in the same way as are now the remains of animals. He illustrated his point by tables showing the distribution of plants in the richer floras, especially in the Carboniferous and Mesozoic. He further dwelt on the identity and dissimilarity of the fossil plants found in the American Triassic basins, and exhibited tables giving the number of species peculiar and common to each. In conclusion Prof. Ward pointed out a few of the conclusions that could be deduced from the facts given.

Prof. Safford exhibited some bones of Megalonyx, lately found in Big Bone cave, Tenn. These he believed to be complementary to those described many years ago from the same place, by the late Dr. Leidy. Some of these, as in the former case, retained portions of cartilage indicating no very ancient date. In the account of this animal recently given in the pages of the GEOLOGIST, it was stated that the pelvis of Megalonyx was unknown. As Prof. Safford's specimens showed the two iliac bones and a small part of one pubis the above statement is no longer true.

Considerable discussion took place on the existence of the "Cincinnati ice-dam," but little progress was made in settling this vexed question. In this connection we may notice another topic on which considerable difference of opinion was manifested, namely, the attitude of the continent during the Pleistocene era. The extreme party on one side advocated an elevation of 3,000 feet, and hinted that twice as much was possible, while the other party could see cause and evidence for no changes of level so great. Testimony on this subject is coming gradually to light, and the Pleistocene is assuming a more and more complex character and history from day to day. Some deep borings, for example, one at Rochester, N. Y., and one at New Portage, near Akron, were described, the former by Prof. Fairchild, and the latter by Prof. Claypole. Mr. Van Hise presented a paper on the relations of the Algonkian and Archæan in the Northwest, and Capt. Shufeldt one on the avifauna of Oregon, giving an account of some very large fossil birds.

Several other papers of considerable interest by various authors, concluded an interesting and useful, though not an eventful meeting.

GEOLOGICAL SOCIETY OF AMERICA. Following the Association or rather imbedded in it came the meeting of the Geological Society of America. A new and large detachment of American geologists mustered to reinforce those previously present and work began again with new energy but in a slightly different direction. Numerous foreign geologists also began to arrive for the Congress that was to meet in a day or two and great confusion of tongues prevailed in the halls and corridors. A very agreeable feature of these gatherings is the opportunity which they afford of seeing the faces and feeling the handgrasp of men with whom correspondence and community of employment have long made many familiar.

A very fitting commencement of the proceedings was the reading of a memorial of the late president of the society by his brother, Prof. N. H. Winchell. This presented to the members an excellent sketch of the life and works of one of the most eminent geologists of this country, who did much to popularize the science among teachers and in the general community.

A very valuable and closely condensed account of the geology of S. America was presented by Dr. Gustaf Steinmann of the University of Freiburg, Germany. In it was brought out the fact that the well recognized *Glossopteris* flora of Australia, etc., also occurred in S. America,

so that the land over which this flora extended was wide enough to include S. America. This gives a Mesozoic cast to the fossil Carboniferous flora of the greater part of the southern hemisphere and probably to some parts of the northern and indicates apparently, as Prof. L. F. Ward pointed out, that in or after the Permian period of glaciation the old cryptogamic and coniferous flora yielded to its more adaptive successor and retreated to the northward where it held its ground for awhile.

The Carboniferous of S. America is in many places, said the speaker, covered with marine Liassic beds, often conformable and containing genera such as those of Europe. And the whole Mesozoic series is intercalated with immense masses of volcanic material.

Dr. August Rothpletz of the University of Munich, read an able paper on the Mesozoic formation at the E. Indian islands, Timor and Rotti. A rich Carboniferous flora is found there also characterized by Glossopteris, and the speaker indicated that the southern area had been long isolated from the northern so that passage either way was not possible.

Mr. A. Harker, of Cambridge, England, read a learned but technical paper on thermometamorphism in igneous rocks.

Prof. L. F. Ward presented a paper on the relations of the fossil plants of the Triassic in America, in which he pointed out with the aid of tables the nature of species peculiar and common to the different Triassic basins not known in this country.

Mr. Joseph F. James gave a summary of the literature and history of *Scolithus* pointing out its little value in the classification of rocks and suggested that the species should be named from their horizon rather than the horizon from the species.

A paper by Mr. R. A. F. Penrose, on the Tertiary iron ores of Ark. and Texas., gave the physical and stratigraphic details of their occurrence. Mr. Hay described some "sandstone dykes" in northwestern Nebraska.

The evening was at first given to two papers on orographic geology. The first was read by Mr. Cadell of Edinburgh on some experimental reproductions of Scottish mountain structures and the second by Mr. Bailey Willis on the mechanics of Appalachian mountain structure. Both were illustrated by lantern views and were intended to show the production of faults and thrust-planes in strata under tangential compression.

A series of beautiful and very instructive views of the Muir glacier in Alaska by Mr. Cushing closed the evening. These were shown by the lime light and formed a marked feature of the meeting to all who saw them. M. Cushing's estimate, it may be remarked, of the rate of motion of the glacier reduces the figures of Prof. Wright from 70 feet per day to 7 feet and even to less, and he also stated that it had retreated a full half mile in the four years since Prof. Wright's visit.

On Tuesday morning Dr. Fredrich Schmidt, of the Academy of Science, St. Petersburgh, read a paper on the Eurypterus beds of Oesel compared with those of N. America.

The Baron de Geer, of Stockholm, gave an interesting and valuable account of the Quaternary changes of level in Sweden which elicited several remarks on their resemblance to contemporaneous changes in this country. He instanced several extensive oscillations before, during or after the Gracial era, during some of which great part of the country was below the sea and other parts reduced to the form of islands. Prof. Krassnof discussed the "black earth" of southern Russia, and its resemblance to the soils of the American prairies. This elicited a discussion on the complexity of the problem of these soils, and the morning session closed with a short paper read in French by Prof. Stefanescu, of the University of Bucharest, on the occurrence of Dinotherium in Roumania.

Pres. T. C. Chamberlin in the afternoon summarized the standing of several of the theories which have been suggested to explain the occurrence of the Ice age. After stating that the hypothesis of Croll now fails to account for the phenomena, at least on this continent, he hastily sketched the theory of elevation as the cause of the cold, and offered as in his view most probable a change of the axis of the earth's rotation. In the discussion that followed some opposition was developed and it was apparent that the geologists present were far from agreement on the subject, a result that might have been anticipated.

The society was divided into two sections in order to render the completion of the program possible. Papers on the drift and kindred subjects were read in one room and the rest in another. Mr. R. D Salisbury mentioned the occurrence of the preglacial Orange sand of the Mississippi in Illinois and Indiana and at levels considerably above the present river, indicating the attitude of the country at that time. He also stated the occurrence of an older drift outside the so-called terminal moraine in New Jersey and referable to the earliest drift of which we have any knowledge. Mr. S. suggested further that though we are accustomed to speak of two glacial eras, yet there may have been three, the earliest of which is represented by the deposits which he described, the second by the silt layer and the third by the moraine.

Petrographical papers were presented by Mr. J. F. Kemp and Mr. O. A. Derby. Mr. R. T. Hill contributed one on the geology of Texas and New Mexico and Mr. Winslow another on the condition of deposition of the Missouri Coal Measures.

Prof. Safford exhibited some interesting specimens consisting of the bones of a Megalonyx, from Big Bone lick, Ky. These he considered to be the remainder of the skeleton of the animal discovered by Leidy in his "Contributions." Like those some of them showed the remains of cartilage indicating no excessively ancient date.

In a short address Prof. E. W. Claypole related the discovery of a deep preglacial channel previously unsuspected. It is about five miles from Akron, O. The auger went down nearly 400 feet before the rock was reached showing that at this point the old river bed was cut down to the level of lake Erie though 40 miles distant.

The society is now in the third year of its existence and numbers more than 200 members scattered over the country from the Atlantic to the Pacific. Two volumes of transactions have been published embodying the results of researches in almost every field of geology. They may be obtained from the secretary, Prof. H. S. Fairchild, of Rochester, N. Y., to whom also should be addressed all applications for membership.

A SPECIAL PARTY will study the Pleistocene of the southern coastal plain from Alabama to Mexico, leaving Washington immediately after the adjournment of the International Congress of Geologists. The party embraces the following: W. J. McGee, E. W. Hilgard, Eugene Smith, J. A. Holmes, Lester F. Ward and Robert T. Hill. Subsequently the relations of the "Trinity" of Texas, and the "Potomac" of Virginia, will be investigated in the field by Messrs. Ward and Hill.

OF THE NINETY FOREIGN DELEGATES to the International Congress of Geologists present at the Washington session, sixty-three participated in the western excursion to the Yellowstone Park and the Rocky mountains.

AT THE MEETING OF THE COMMITTEE OF ORGANIZATION of the National Association of Government Geologists, Saturday evening, August 29, the secretary, Mr. Arthur Winslow, was instructed to draft a Constitution and By-Laws, to be submitted to the committee at a meeting to be called in connection with the Annual meeting of the Geological Society in December next.

The secretary was further requested to notify all State Geologists of this movement towards organization, and to invite them to be present at the next meeting.

PROF. O. C. MARSH HAS CROSSED THE ROCKY MOUNTAINS twenty-seven times, in quest of fossil vertebrate skeletons, first in 1868, and remarked that he hopes to cross them as many times more.

PROF. E. H. BARBOUR, GRINNELL, IOWA, has accepted the professorship of geology in the State University of Nebraska, at Lincoln.

DR. THEO. B. COMSTOCK, OF THE TEXAS GEOLOGICAL SURVEY, has been appointed director of the School of Mines, Tucson, Arizona.

THE BASIN OF ITASCA LAKE, which flows northward and is enclosed on all other sides by morainic accumulations, was formerly filled by a lake of much larger dimensions. Mr. J. V. Brower, in his official report on the new Itasca park, established by the last session of the Minnesota Legislature, describes the valley, and proposes for the extinct lake, which doubtless subsided to the dimensions of the present lake on the withdrawal of the ice of the Glacial epoch from the region, the name "lake Upham," in recognition of the efficient work of Mr. Upham on the glacial geology of the state.

THE

AMERICAN GEOLOGIST

VOL. VIII. OCTOBER, 1891. No. 4.

BEECHERELLA A NEW GENUS OF LOWER HELDERBERG OSTRACODA.

By E. O. ULRICH, Newport, Ky.

About the beginning of this year I was greatly pleased at receiving from Dr. C. E. Beecher, of New Haven, Conn., a not only bountiful but an exquisitely preserved lot of Lower Helderberg Ostracoda; and in a few days thereafter another series of the same, scarcely less extensive and excellent, from my well-tried friend, Mr. Charles Schuchert. To both of these esteemed gentlemen I am under the greatest obligations because of their untiring efforts to aid me in my studies of these minute fossils. The extreme liberality with which they have supplied me with specimens, the picking out of which has doubtless consumed much of their time, is conclusive evidence of an unselfish desire to advance science that is as unusual as it is commendable.

These Lower Helderberg specimens are all silicified and have, by the judicious use of acids, been freed from the hard, stony matrix that originally enclosed them. They are, therefore, unusually perfect in their preservation, and exceptionally adapted for detailed study. In these respects they are but little, if at all, inferior to the beautiful things washed out of the Falls of the Ohio "Bryozoa bed," some of which I described lately (Jour. Cin. Soc. Nat. Hist. Vol. XIII, 1890-91).

In the "introduction" to that paper I made some remarks on the distribution of the known American paleozoic Ostracoda, stating also that numerous forms may be looked for in our Upper Silurian and Carboniferous deposits. The truth of this predic-

tion, in the first case at least, has received almost startling confirmation by these discoveries of Dr. Beecher and Mr. Schuchert; and in the second case a good beginning has been made by Dr. Herman Herzer, who recently sent me a quantity of shales and limestones, from the Coal Measures of Ohio, that are largely composed of the shells of Ostracoda.

In the present paper I am obliged to restrict my observations to a small but very remarkable group of species, not represented, so far as we know, outside of the Lower Helderberg rocks of New York. They seem clearly to indicate a new genus that I propose naming *Beecherella*, in recognition of the discoverer's paleontological labors. From a collector's standpoint, a striking feature about these species is the rarity of the individuals representing the six or seven distinguishable forms. Of only one have we as many as five valves, while of the others the number seen is three, two, or only one!

The associated species, on the contrary, are in most cases numerously represented. Especially is this true of *Æchmina*, of which there are at least two species, probably identical with the English and Scandinavian *Æ. bovina* and *Æ. cuspidata*. Among the others we may mention *Beyrichia*, *Kloedenia*, *Bollia* (?), *Moorea*, *Bythocypris*, etc., each with from one to four or more species, and most of them, if not all, with more or less obvious relations to Wenlock species. But this bears upon a too important question—*i. e.*, the correlation of American and European strata—to permit of definite assertions previous to much more careful and detailed comparisons than I have yet found time to make. I am however now, through the kindness of Mr. G. R. Vine and Prof. T. Rupert Jones, fairly well equipped to enter upon such comparisons, and hope in the near future to undertake them.

Beecherella, n. gen.

Carapace small, elongate, boat-shaped to ovate, moderately convex, more or less inequivalve. Dorsal margin varying from nearly straight to strongly convex; back sometimes flattened, with a sharply defined carina on one or both valves, giving them a triangular shape in cross-sections; in other cases the dorsal slope is merely convex. Antero-dorsal extremity acuminate, often drawn out into a long spine; spine strongest on the right valve, sometimes absent entirely on the left valve. Posterior extremity

acuminate or rounded. Ventral edge gently convex, occasionally straightened in the middle. Hingement simple, the dorsal edge of the right valve especially somewhat thickened and in the central portion slightly overlapping the left valve.

Type, *Beecherella carinata*, n. sp.

Some of the species about to be described under this generic name deviate rather widely from the one selected as the type. Only one feature is common to them all—the anterior spine.

The value of this character as an indication of true generic affinity may have been over estimated, and it is therefore possible that more than one generic group is represented. This is however a point that cannot as yet be determined, since, without more material of these and other species that sooner or later is certain to be discovered, it is not possible to pick out with certainty the really diagnostic characters.

B. ovata may seem the farthest removed from *B. carinata*, but *B. subtumida* is clearly an intermediate form, as is also *B. cristata*. *B. navicula* and *angularis*, however, differ from all the others in this, that the anterior spine is a prolongation of the dorsal edge instead of the dorsal carina or of the anterior slope. It is here, perhaps that another genus is indicated.

Respecting the position of *Beecherella* I find myself quite unable to arrive at any satisfactory conclusion. Many of the Cypridinidæ it is true, have an anterior spine or hook, but here the resemblance ceases. The thin shells of the Cypridæ also are quite different, though one form of *Cypris* has been described as having a front spine (*C. cornigera*, Jones Geol. Mag. 1888, p. 336, fig. 1a–f), and *Bairdia* occasionally presents resemblances. And then the *Leperditiidæ*, a family that already includes many odd forms, does not, so far as I can see, contain anything throwing light upon the question. At present, therefore, I am obliged to view *Beecherella* as one of those groups of fossils, so frequently presented to the student of paleozoic paleontology, that baffle the most careful efforts of the systematist to classify successfully.

Beecherella carinata, n. sp.

PLATE II, FIGS. 1–4.

Size: a large right valve; greatest length, 3.60 mm.; greatest hight, 0.77 mm.; greatest thickness, 0.50 mm.; length of anterior spine about 0.65 mm.; greatest length of valve at inner edge, 2.90 mm.

Valves elongate, boat-shaped, extremities acuminate, subequal the anterior spine strong, projecting greatly beyond the end of the hinge margin; from this spine a sharply defined thin, and gently curved dorsal ridge or carina, extends backward to and a little beyond the angular postero-dorsal extremity. A sharp impression extends a short distance obliquely downward from this extremity of the ridge. Back flattened except where it runs into the terminal spines; a faint channel along the edge. Ventral edge nearly straight, curving uniformly upward at each end. Surface without ornamentation, with point of greatest convexity (thickness) at the dorsal carina about midway of the length.

In a view of the inner side the dorsal edge is strongly convex, and the anterior junction with the ventral edge very acute and occurring beneath or about the middle of the hight. The largest and best of the valves seen presents a feature about which I could not satisfy myself that it really belongs to the valve. I refer to the thin oblique diaphragm-like structure shown in the right half of fig. 2. If it is really a normal structure then it appears to be restricted to the right valve, as I fail to notice any sign of it in a well preserved left valve. Nor can I detect any sign of such a diaphragm in the other species.

The elongate form, sharply carinate back, acute posterior end, and the strength of the anterior spine are the distinguishing features of this species. It should require but a glance to separate it from all of its known associates.

Formation and locality: Lower Helderberg group, Albany county, N. Y. Types in Dr. C. E. Beecher's collection.

Beecherella subtumida, n. sp

PLATE II, FIGS. 5–7.

Size of right valve: greatest length, 1.90 mm.; greatest hight. 0.70 mm.; thickness, 0.55 mm.; length of valve at inner edge, 1.53 mm.; projection of spine beyond anterior edge about 0.35 mm.

Valves elongate-ovate, slightly widest in the posterior half; extremities, excluding the anterior spine, subequal, the posterior a little the bluntest of the two. Dorsal margin straight, sharply rounded at the postero-dorsal angle, and very slightly bent down where it passes into the strongly projecting anterior spine. Antero-ventral margin (in a side view) straight or faintly concave to the end of the spine. Ventral edge, uniformly convex, from

base of anterior spine to point on posterior edge one-third of hight of valve beneath the dorsal line, the curve corresponding to something near a one-third segment of a circle. Posterior end most produced above, with a flattened border or flange projecting beyond the inner or contact edge; flange widest above, vanishing in the lower third. Back strongly convex, without carina, but with a shallow channel close to the edge. Surface smooth, valves tumid, with point of greatest thickness a little above the middle. In a view of the inner side the contact edges form an elongate-oval, with the anterior end sharply rounded or sub-acute, and the dorsal side straighter than the ventral.

This species is too obviously distinct from the preceding to require comparisons. *B. ovata* has much wider valves, with quite different surface contour; while *B. cristata* has the dorsal margin more convex, and a thin carina or crest on the dorsal slope.

Formation and locality: Same as preceding.

Type in Dr. C. E. Beecher's collection.

Beecherella subtumida, var. intermedia, n. var.

PLATE II, FIG. 15.

Size of right valve: Length (excluding spine) about 1.17 mm.; hight, 0.63 mm.

This name is proposed provisionally for a single right valve, that, being a little imperfect at the anterior end, I think it wisest to view with conservative judgment. At first I was inclined to regard it as a young right valve of *B. ovata*, but on re-examination that view lost probability, and I now believe that its relations are nearer *B. subtumida*, with the chances strongly in favor of ultimate specific separation from both. A comparison of figs. 5 and 15 shows that the latter is comparatively shorter, the antero-dorsal angle abruptly curved instead of gently declining, the anterior end probably blunter, and the ventral edge a little more convex. In the two points last mentioned the shape is more nearly as in *B. ovata* (see fig. 14) with which it agrees further in having the anterior spine less produced beyond the end of the valve, and its base situated farther back on the antero-dorsal slope—not however as much so as in that species. Its surface is less and more uniformly convex than *B. subtumida*, while *B. ovata* has a low cardinal ridge running backward from the spine, and a shallow

depression beneath it, neither of which is represented in var. *intermedia.*

Formation and locality: Same as preceding.

Collected by Mr. Chas. Schuchert, but now in the author's cabinet.

Beecherella ovata, n. sp.

PLATE II, FIGS 13 AND 14.

Size of left valve: Length, about 1.87 mm.; hight, 1.10 mm.; greatest thickness, 0.50 mm.; length of spine, about 0.60 mm.; projection of same beyond anterior edge, about 0.30 mm.

Of this species the left valve illustrated on the accompanying plate is all that has so far been discovered. It is a little imperfect at the posterior end but the remainder is in sufficiently good condition to justify description.

Left valve ovate, widest posteriorly, with point of greatest hight, about midway between the extremities. Dorsal edge gently convex, posterior end semicircular, anterior end sharply rounded and most prominent just beneath the spine; ventral edge rather strongly convex, with the curve in the antero-ventral region somewhat straightened. Anterior spine rather long and slender, but projecting only about half its length beyond the anterior edge; continuing backward from base of spine a low rounded dorsal ridge is traceable across the middle third of the length of the valve. From this ridge to the dorsal edge the slope is abrupt, while just beneath it a shallow depression, widest and deepest at a point a little in front and above the center of the valve, is noticeable. Just behind the center an obtuse elevation constitutes the point of greatest thickness. Anterior, ventral, and posterior slopes gently convex. Surface without ornamentation.

Formation and locality: Same as preceding.

Type in Dr. C. E. Beecher's collection.

Beecherella cristata, n. sp.

PLATE II, FIGS. 16–19.

Size of entire carapace: Length, including anterior spine, 1.27 mm.; length, without spine, 1.10 mm.; hight, 0.49 mm.; thickness, 0.47 mm.

Carapace elongate ovate, narrowly rounded behind, acuminate in front. Dorsal and ventral sides nearly equally convex. In a ventral view the two valves are about equally convex, with the point of greatest thickness near the middle. Valves unlike, the left without spine or crest, but with a narrow flattened border at

each end. Right valve with a faint dorsal overlap, a rather small subterminal anterior spine, and behind it a thin crest-like longitudinal ridge situated about midway between the center of the valve and its dorsal edge.

This is the only species of the genus of which the two valves have been found in conjunction. They are so different that if found separate they would scarcely have been referred to the same species. Indeed, the spineless left valve would most likely have been regarded as *Bythocypris.* The two valves are known also of *B. carinata* and *B. navicula*, but in these the anterior spine of the left valve is merely somewhat smaller than that of the right, while the *B. ovata*, of which the left valve only is known, this spine is very well developed. *B. subtumida*, known only from right valves, is evidently a related form, and it is possible that in it too the left valve is spineless, which may account for its non-recognition.

Formation and locality: Same as preceding.

Type picked from fine residue sent me by Mr. Chas. Schuchert, and now in my cabinet.

Beecherella navicula, n. sp.

PLATE II, FIGS. 8 AND 9.

Size of left valve: Length from extremity of spine to posterior margin, 3.4 mm.; hight, 0.7 mm.

Valves elongate, boat-shaped, the dorsal and ventral margins sub-parallel, the former long, gently convex, anteriorly drawn out into a long spine projecting forward and a little upward like the bowsprit of a boat; posteriorly bending down into the sharply rounded posterior margin. Anterior end sloping backward from the base of the spine into the ventral edge. The latter is straight in the middle, and gently curved upward behind. Surface moderately convex, the dorsal slope the most abrupt. The spine of the right valve slightly stronger and longer than that of the left.

On the inner side the dorsal edge is thickened, especially in front where it forms the projecting spine. Running nearly parallel with the anterior edge a ridge, quite distinct in the left valve, but much less so in the right, is to be observed. From the nature of the parts forming the anterior half of the valves it appears that when joined and the carapace closed an opening must exist just beneath the spines.

There is little probability of confusing this with any of the

preceding species. The internal differences are so striking that a generic rather than specific separation is suggested.

Formation and locality: Same as preceding.

Types in Dr. C. E. Beecher's collection.

Beecherella angularis, n. sp.

PLATE II, FIGS. 10–12.

Size of right valve: Length 1.45 mm.; hight, 0.75 mm.; thickness, 0.38 mm.

Valves obliquely acuminate-ovate, in a side view, triangular in cross-section, the dorsal side being nearly straight, with a wide, subtriangular flat or slightly concave back, the posterior third semicircular, the anterior margin gently curved and sloping backward from the pointed antero-dorsal extremity into the neatly rounded ventral margin. Point of greatest thickness just beneath the dorsal ridge from which the surface slopes with a gentle convexity to the free margins.

The general expression of the only valve of this species seen except that it is inequilateral, resembles that of the ventral valve of a minute *Spirifera* with a wide flat area. The possession of such a flattened back recalls *B. carinata*, but the relationship can only be remote since they differ so greatly in all other respects. Nor do any of the other species approach *B. angularis* sufficiently to make comparisons either necessary or desirable.

Formation and locality: Same as preceding.

Type in Dr. C. E. Beecher's collection.

EXPLANATION OF PLATE. *

BEECHERELLA CARINATA, n. sp.

Fig. 1. Nearly perfect right valve.

Fig. 2. Interior view of same.

Fig. 3. Dorsal view of same.

Fig. 4. Interior view of a small left valve.

BEECHERELLA SUBTUMIDA, n. sp.

Figs. 5, 6 and 7. Respectively interior, side and dorsal views of a right valve.

BEECHERELLA NAVICULA, n. sp.

Fig. 8. Interior view of a perfect left valve.

Fig. 9. Interior view of the anterior half of a right valve.

BEECHERELLA ANGULATA, n. sp.

Figs. 10, 11 and 12. Interior, end and dorsal views of a right valve. (The dorsal view is too long.)

BEECHERELLA OVATA, n. sp.

Figs. 13 and 14. Dorsal and side views of the only specimen, a left valve, seen.

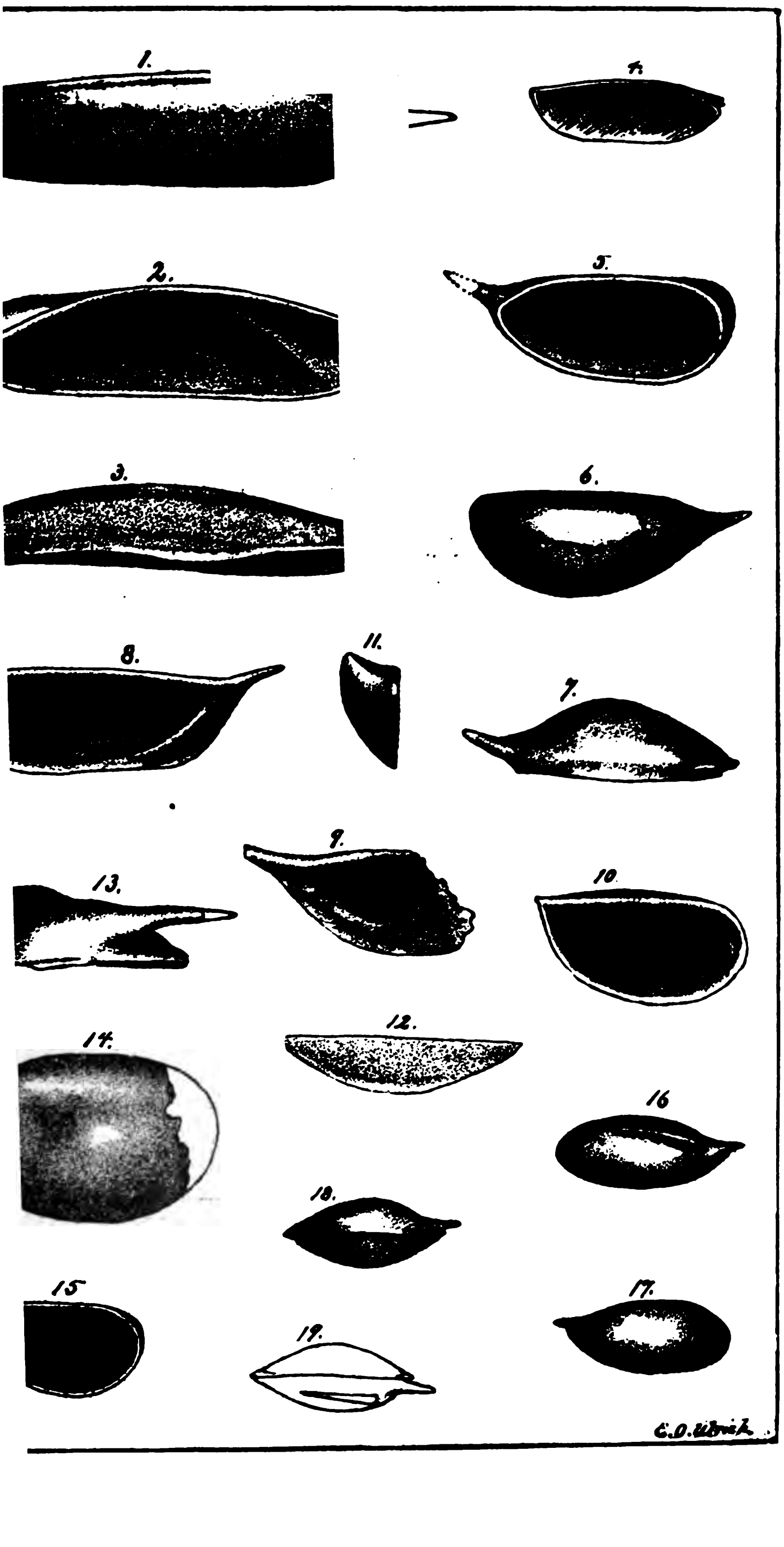
BEECHERELLA SUBTUMIDA, var., INTERMEDIA, n. var.

Fig. 15. View of the interior of a right valve.

BEECHERELLA CRISTATA, n. sp.

Figs. 16, 17, 18 and 19. Respectively right side, left side, ventral and dorsal views of a perfect carapace.

* All the figures are enlarged 20 diameters.



NOTES ON THE MUIR GLACIER REGION, ALASKA, AND ITS GEOLOGY.

By H. P. Cushing, Cleveland, O.

CONTENTS.

INTRODUCTION.

In the spring of 1890 a party was organized by Dr. H. F. Reid, of the Case School of applied Science, Cleveland, O., to proceed to Glacier bay, Alaska, for the purpose of mapping the basin of the Muir glacier, and of making as thorough an exploration as the time at their disposal would permit. The party consisted of Dr. Reid, Messrs. H. McBride, J. F. Morse, C. A. Adams, of Cleveland and R. L. Casement, of Painesville, O., and the writer. We reached Glacier bay on the 1st of July, and were fortunate in finding Prof. John Muir already in camp there, with Mr. Loomis, of Seattle, Wash., as a companion. Our stay was made vastly more pleasant and profitable by Mr. Muir's presence and knowledge of the region. He made the first exploration of the amphitheatre occupied by the main mass of the glacier (see map), leaving camp in the middle of July, and in a solitary trip of ten days duration, passing completely around this amphitheatre. Our party had been preceded in work at this point by Prof. G. F. Wright, who spent a month here in 1886. His retults are well known and his work was of value to us in many ways.

Work in an unknown and difficult region of considerable extent must necessarily be largely the work of the scout. Detailed ob-

servations are out of the question. It is believed that more genaral ones are of sufficient interest to be worthy of record.

DESCRIPTION OF THE REGION.

Glacier bay is a narrow arm of the sea about thirty miles long and five to eight miles wide projecting northwestwardly from Cross sound. Between it and the Pacific lies a rather narrow peninsula occupied by the Fairweather range of mountains, and two minor ranges west of it. East of the bay is another narrow and mountainous peninsula separating it from Lynn canal. Near its head it bifurcates into bay Glacier proper and Muir inlet, the latter projecting from the main bay in a northerly direction. It is from three to four miles long and from one to two miles wide. Into its head Muir glacier advances. The mountains adjoining the bay are mainly low, rounded spurs rarely exceeding 3,000 feet in hight, but present occasional sharp peaks rising from 5,000 to 6,000 feet above tide. Their northern slopes are often permanently snow-clad, but southern exposures are entirely free from snow in summer, and gay with a profusion of flowers. To an observer on one of the spurs on the eastern side of Muir inlet a spectacle of unparalleled grandeur is presented. To the west across Glacier bay rise two low ranges of mountains and beyond loom up the giants of the Fairweather range, beautiful white, snow-clad peaks. To the east and northeast are the White mountains lying between Glacier bay and Lynn canal. To the north and northwest the whole of the vast amphitheatre occupied by Muir glacier lies before the eye, with its encircling mountains, and the larger number of the many valley glaciers that pour their ice into this amphitheatre. The great branches that come in from the northwest may be followed by the eye for great distances. As the ice in the amphitheatre advances toward Muir inlet it becomes confined within narrow limits. The amphitheatre has a breadth of from twelve to fifteen miles or more. In order to reach the inlet the ice occupying it is forced through a mountain gap less than three miles wide. At the present time the ice front barely reaches the narrowest portion of this gap. The waters of Muir inlet do not wash the bases of the mountains. A deposit of sand and gravel with a width of from one-half to three-fourths of a mile lies between the two on each side of the inlet. As a result only the central portion of the glacier terminates in the water. This central portion is tremendously crevassed and broken. On each

side the glacier ends upon these soft deposits, diminishing in thickness to an edge. These side portions of the glacier, especially the eastern side, are as notably smooth as the central portion is broken. Near the front of the glacier three low mountains protrude from the ice which entirely surrounds them. On these were Dr. Reid's stations G, H and I. The western one, G, is much the largest and highest, and forms a conspicuous feature in the landscape seen in looking toward the ice from the bay.

TRIBUTARIES OF MUIR GLACIER.

The greater portion of the ice which reaches the front of Muir glacier at the present day is supplied by the two great ice-streams which enter the basin from the northwest,* Muir glacier proper and the northwestern branch. The former is the larger, has a length of certainly thirty-five miles and probably more, and is deeply and abundantly crevassed for a great distance back from the ice front. The central and larger portion of the ice front derives its ice from this source. The northwestern branch is only second in size to this one. Its length is not so great nor its crevasses so numerous and profound. Its ice reaches Muir inlet to the west of the ice from Muir glacier proper. The next most considerable tributaries are the two northern branches. These have great length but will not compare in size with the last two. They furnish the ice which breaks away into the water at the eastern corner of the inlet. The Western branch is quite completely separated from the rest of the glaciers by the numerous low mountains that protrude from the ice. Its interesting features are its numerous connections with its Northwestern branch through the mountain gaps, and its source on a saddle from which ice flows in both directions, a feature shared by other glaciers in the basin. The ice from this branch does not enter the water, but dies out on the gravel deposit which forms the western shore of Muir inlet.

Eastern branches.—That portion of the amphitheatre of Muir glacier lying east of a line drawn from Snow dome to the eastern corner of the inlet is occupied by a mass of ice nearly inert, and slowly rotting where it lies. Stakes placed across it about half a mile back from the front, at the end of three weeks showed either no motion at all, or else an extremely slight one. The surface of all this portion of the glacier is extremely smooth. Crevasses

*See map.

occur, but in general are mere cracks. None are found which are not readily to be stepped over. Everything points to rapid decadence. Points of interest increase as the various valleys tributary to this part of the glacier are examined.

The Dirt Glacier.—The first valley opening into this part of the glacial amphitheatre as its edge is followed is occupied by a small glacier, to which the name Dirt glacier was applied, because the ice in the whole lower half of the valley is completely and heavily covered with debris from the rapidly disintegrating mountains at its sides. The upper half of the valley discloses an extremely pretty, small, white glacier with heavy lateral moraines which gradually increase in width with the result mentioned above. This glacier at the present time has not sufficient vitality to send its ice beyond its own valley. Its lower portion is without perceptible motion, and has melted away considerably from the mountain sides.

The White glacier.—The next valley is occupied by a very beautiful little glacier of a dazzling white appearance, with two medial moraines which present a very striking appearance from a distance on account of their graceful curves. This glacier still possesses considerable vitality, sending its ice clear to the Dirt glacier valley. In entering the main basin its ice makes a sharp turn of 90°, causing a depression of its surface at the concave side of the bend with a corresponding slight elevation at the convex side.

The Southeastern branch.—For our present purpose the point of interest of this next succeeding glacier is its present vitality. It really comprises two glaciers, the first of which is somewhat the larger of the two. This sends its ice not quite to the White glacier valley, dying out against the mountain side just before that valley is reached. Ice from the other branch extends but little further, pinching out between ice from Main valley and the White glacier, opposite the entrance to White glacier valley.

Main valley.—The greater portion of the ice occupying the eastern part of Muir glacier amphitheatre has emerged from the large valley called Main valley. At present many curious features are exibited here. No ice is visible in the upper portion of this valley or in the valleys tributary to it. The comparatively narrow ridge back of Tree mountain which separates Main valley from the snow fields of the Southeastern branch is deeply

snow-covered on the one side, and perfectly bare on the other. Some cause not evident has locally produced a greater and more rapid disappearance of snow and ice from the vicinity of Main valley than has elsewhere taken place. Snow fields occur on Mt. Young, the highest and most imposing mountain in the vicinity. But these form very small glaciers and the valleys enclosing Mt. Young are free from ice. The ice occupying the upper part of Main valley terminates abruptly at the edge of a long, narrow lake—Main lake—whose long axis is at a high angle with the trend of the valley, and which occupies nearly its entire width. The eastern shore of the lake is made up of glacial debris modified by water, and such deposits exist in considerable force in the tributary valleys beyond. Small bergs, evidently derived from the end of the glacier, float in the waters of the lake, and strand on its shores. From its lower end a stream of water issues, flowing away toward Lynn canal. The lake is held in place by the thickness of the soft deposits on its eastern shore.

The moraines in Main valley run directly to the shores of Main lake, there ending abruptly. That the rock masses from which they derived their contents, lie to the east, is clear from the nature of the contents. Hence the ice must formerly have completely filled Main valley and come from the tributary valleys to the east. At the present time the supply of ice in the valley is renewed from no source whatever, except for the snow which falls upon its surface in winter. The highest part of the surface of the ice at present is some distance west of the lake. Somewhere beneath this ice, lies the divide for this valley between Glacier bay and Lynn canal. The stream flowing from Main lake flows into Lynn canal. It is possible that Main lake lies just on the Glacier bay side of the divide. That being the case, the draining of the lake would be indefinitely postponed. In the period of greater life of the glacier, the glacier occupying the stream valley, and the upper part of Main valley must have had a rising slope for its floor, and the reason for its movement in this direction furnishes an interesting problem to be solved. At the present time the whole mass of ice is practically inert, but it seems inevitable that there must be a slow flow of the ice in both directions away from the highest point. This movement would add to the general lowering of the surface of the ice produced by melting. It must also tend to an attenuation of the moraines spread upon the surface.

Another testimony to the inert condition of the ice in Main valley and vicinity is the shrinkage of the ice away from the mountain slopes which border it. This shrinkage must be partially counteracted by the slow movement just spoken of, but it is very conspicuous. The ice is rarely in contact with the mountains, but has withdrawn a few feet, leaving gaps into which an astonishing amount of debris has been tumbled.

Berg lake.—Two small valleys open into Main valley from the northeast. The most easterly of these is occupied by Berg lake, presenting an excellent example of a valley lake whose waters hold their position in virtue of an ice barrier across the valley mouth. In this lake also float ice bergs derived from the ice barrier which holds the lake in place. Two enormous moraines extend from the mouth of this valley to the ice front. Their great size compared to the size of the valley in which they must originally have been formed is a matter worthy of comment Here also the slow creep of the ice away from its highest point must be felt, and accounts for the occasional berg which the ice furnishes to the lake. What becomes of the surplus water of the lake is not known, but it seems probable that it must find its way into Main lake. A comparatively slight extension of the latter would cause the two to coalesce. The same cause that has removed the ice from the upper part of Main valley has removed it from Berg lake valley. Glaciers ordinarily retreat up their valleys. Here the opposite course of proceedure seems to have obtained, and the glaciers have disappeared from the small valleys while thick ice remains in the larger one into which the others formerly poured their supply.

The Girdled glacier.—The westerly of the two valleys spoken of is occupied by a very beautiful little white glacier, with a very steep slope. The clean character of its surface and the small amount of debris which it brings down, are as astonishing on the one hand, as are the great moraines which have come out of Berg lake valley on the other. This glacier received its name from Dr. Reid because of the curious disposition of the moraines around the end of its valley. A moraine curves gracefully around its front, from the end of the ridge on the west, to the end of the ridge on the east side of its valley. Another moraine, parallel to this, emerges from Granite canon to the west, curves around outside of the first, and dies out against the mountain

side just to the west of Berg lake valley. These moraines both lie on the surface of the ice lying in the main valley. Ice from the Girdled glacier seems just to reach this, but does not pass into Main valley, nor can it have done so for some little time.

Granite canon.—The valley to which Mr. Muir applied this name is, barring Main valley, the largest one opening into the eastern part of the Muir glacier amphitheatre. It is a rather gloomy looking valley, bordered by low mountains with somewhat precipitous slopes. These are dotted with patches of snow lying in sheltered depressions, but at present give rise to no glaciers. Hence the ice lying in Granite canon presents the same features as that in Main valley. The ice is inert. It has no feeders. It has disappeared from the upper portions of the valley while yet lying in considerable force in the lower portion. It diminishes in altitude toward the head of the canon, the highest point in the vicinity, lying nearly three miles south of the entrance. About four miles up the canon the end of a lake is visible, lying in a side valley opening into the western side of the canon. Though only the end of the lake was visible the nature of the country surrounding it clearly indicates that the lake bears the same relation to Granite canon that Berg lake does to Main valley, viz: that its waters are held in place by the ice barrier across the front of its valley. The same cause has been at work in both places. That the ice formerly moved out of Granite canon, and did so for a vast length of time is indubitably shown by the material of which the great moraine that issues from it is composed. The great proportion of this material is diorite which is only found in place in the mountains enclosing the upper portions of the valleys that open into the glacier's amphitheatre from the east and north. Ice certainly flowed out from Granite canon long enough to carry this moraine clear to the present front of Muir glacier and beyond. The outward flow of the ice from Main valley must have ceased before the stoppage of the flow from Granite canon. The moraine which emerges from Granite canon and passes around the front of the Girdled glacier proves this. On the cessation of the flow from Main valley the ice must have receded somewhat from the mountain flanks. The eastern portion of the ice flowing out from Granite canon would then have encountered less resistance in this direction, and a portion of it would deflect from the main mass

and follow this new direction. The short moraine which passes just across the front of the Girdled glacier inside of this one was formed at the same time, mainly from material from the rapidly disintegrating mountain ridge west of the mouth of the Girdled glacier. That the outward flow of the Granite canon glacier did not continue long after the stoppage of the flow from Main valley. is shown by the short distance traversed by the moraine emerging from the canon and flowing in this direction.

If there is the present slow flow of the ice in Main valley already spoken of, a flow in both directions from the highest point of the ice, there must be a corresponding slow flow of the ice back into Granite canon. Starting at the front of Muir glacier, and proceeding toward the canon, the surface of the ice is found to slowly increase in hight till, about ten miles from the front, an altitude of about 1,300 feet A. T. is reached. From this point further progress to the northwest is over a descending surface. This descent continues up Granite canon as far as the eye can see.

Two small glaciers appear on the southern slope of the mountain mass lying between Granite canon and the First Northern branch. The ~~most~~ western of the two—marked Glacier 9 upon the map—merits brief attention. It has retreated some little distance up its valley, and its lower portion is covered from one side to the other with debris, after the manner of the Dirt glacier. Upon the ice of the main mass in the amphitheatre which lies across the opening of this glacier's valley, a moraine appears curving across the opening from one side to the other, the counterpart of the one in front of the Girdled glacier. The motion appears to have been from the west, the material being supplied from the southern slope of Snow dome, the mountain to the west of this glacier. A recent flow of ice from the First Northern branch across the opening of this valley must have taken place, carrying with it the disintegrated material that fell from Snow dome upon the surface of the ice.

RECENT RECESSION OF THE GLACIER.

The evidence that very recently Muir glacier has had a vastly greater extent is remarkably plain, and has been well summed up by Prof. Wright. The reason for its consideration here, is that further evidence has been procured.

Direct evidence.—Prof. Wright's measurements, and photographs taken by Mr. Baldwin of his party furnish a means of

comparing the position and extent of the glacier in 1886 with its condition in 1890. Mr. Baldwin's photographs of the ice front show that in 1886 its position was at least half a mile further to the south than was the case in 1890. No direct measurements on the ground were possible, and the ice front was of such entirely different shape at the two periods, that, at best, only an average could have been ascertained. The amount of retreat has been greater in the central part of the glacier which terminates in the water, its ice breaking off and floating away, than at the sides, which retreat only by slow melting where they lie. Wright's map and photographs show the seaward portion of the ice extending further to the south than the wings on land, the most southerly point of all being in the centre. In 1890, on the other hand the most southerly points of the ice front were the wings—see map—and the water front was deeply concave, the greatest recession, probably not far from a mile, being near the centre. The amount which the wings have retreated has been comparatively small. The testimony of the officers of the steamers which have been entering Glacier bay since 1883, is unanimous that the ice has retreated considerably since that time, the estimates running from one to two miles. The testimony is credible as a new place for anchorage must be sought every year. Half a mile in four years is a tolerably rapid rate of recession, should it prove to be at all an average one.

The hight of the central portion of the ice front above the water in 1890 was about 250 feet, the same that Prof. Wright records.* This, however, was the hight of his projecting point. To points on the front somewhat back of that, he gives a hight of 300 feet. Soundings as close to the ice front as practicable show about the same depth of water, somewhere in the neighborhood of 600 feet on an average. There has evidently been a considerable shrinkage in thickness in the four years interval. The ice front in 1890 was not far removed in position from the line along which Prof. Wright states it to have had a hight of 408 feet in 1886.† Its greatest hight in 1890 was 250 feet. Wright's photographs indicate also a greater thickness of the ice in the Western branch, judging from the hight to which it rises on the mountain sides adjoining, as compared with that exhibited in the photographs of

*Ice Age in North America. p. 43,
†Ibid., pp. 43 and 49.

the same taken by Dr. Reid and Mr. Morse. As a result of his measurements of the rate of motion of Muir glacier near its front, Prof. Wright announces an average forward movement of the ice into the inlet of forty feet a day, with a maximum of seventy feet.* His method was by sighting on various pinnacles of the deeply crevassed portion of the ice, from day to day. Under Dr. Reid's skillful guidance our party made several efforts to completely cross the ice front and plant flags to serve as accurate points on which to sight. The attempt to entirely cross was unsuccessful, proving a task of the most extreme difficulty, if not impossible. By working out from each side toward the centre, however, the last flag on one side was planted so near to the last flag on the other, that the space between the two was less than the average interval left between the others. The most rapid motion found by Dr. Reid by triangulation upon these flags, was seven feet a day. Undoubtedly the ice was in more rapid motion at the time of Prof. Wright's visit. Its greater thickness and the fact that it was further advanced into the comparatively narrow valley in which Muir inlet lies would necessitate this. But the increased rapidity must have been comparatively small in amount.

Freshness and extent of striæ.—The sides of the mountains bordering Muir inlet are polished and striated with the freshest possible marks up to hights of 2,000 feet. The same is true of the sides and tops of the two low islands which project above the surface of Muir inlet. Naturally the striations decrease gradually in number and strength as the altitude increases owing to the rapid disintegration of the rocks. Above 2,000 feet striæ are occasionally found up to hights as great as 3,500 feet. Only occasional peaks have hights over 3,000 feet, hence when glaciation was at its hight the whole region must have been covered with an icy mantle with only here and there a small steep crag projecting above the general level. In the upper portion of Glacier bay the same freshness of the striæ is observable on the mountain sides and the islands in the bay. Going down the bay the same decrease in number and freshness is observed that is found on increase of altitude. Yet the differences are not as marked as would be the case had the retreat of the ice been a slow

*Ice Age in North America. pp. 48—51.

and prolonged matter. The evidence furnished by the striæ is of a recent and rather rapid retreat of the glacier from a condition of much greater extent.

Condition of the Eastern portion of the glacier.—Tnis has already been treated in considerable detail. The evidence there presented of the great decadence of that portion of the glacier will readily be recalled.

Land slip on the White glacier.—The extension of the White glacier into the main amphitheatre is clearly marked by its very white color and the heavy moraine at its outer side. It ends in front of the Dirt Glacier valley. About two miles above its end its entire breadth is covered for a short distance by a coating of loose debris, which increases in thickness and coaresness toward the mountain side, upon which masses of the same material lie. Some sudden flood or avalanche has hurled this mass of material down the mountain side, and scattered it broadcast over the surface of the ice. The present surface of the ice covered by this material now stands well above the level of the ice not so protected, and presents the characteristic surface of ice so covered; great differences of level appear according to the thickness of the covering, with the prevalent tendency toward the production of sharp ridges and cones. To produce the existing difference of level and character of surface exhibited, a length of time would be necessary which must at least be measured in months. Yet the material lying on the glacier is directly continuous with that on the mountain side, so that little movement can have taken place since the slide occurred.

THE DYING GLACIER.

The Dying glacier lies in a valley from half a mile to a mile wide, which extends from the western shore of Muir inlet through the mountains to Glacier bay. The glacier is a mass of ice nearly three miles long, of unknown thickness, occupying the middle third of the valley. From its eastern end a stream flows into Muir inlet, three and one-half miles distant, through the soft deposits occupying this portion of the valley. The western end of the glacier lies very close to tide water from Glacier bay which extends up the valley for two miles and a half. The highest point of the ice, about 800 feet A. T., is near the centre. From this point the surface slopes evenly in both directions. Two small glaciers, the one north of Pyramid peak, and one from the south

were formerly tributary to this glacier, but it has been some time since either has supplied any ice to it. Its moraines lie in perfectly straight lines from one end of the ice to the other, necessarily being the remnants of the old medials that lay on its surface during a time of greater extent. No moraines appeared traceable to the two glaciers coming in from the sides. There are several of these medial moraines lying on this glacier, indicating its formation from a considerable number of small ice streams. They present one very peculiar feature, that of disappearing for a certain interval. On following one of them it would suddenly be cut off sharply, be absent for a certain distance, and then reappear at the surface with equally startling suddenness. This has taken place once on every moraine. Sometimes two or three moraines exhibit this phenomenon at about the same point, but more often the points of disappearance and reappearance on the various moraines seem independent of one another. Close examination revealed the missing portions of the moraines lying beneath the surface of the ice, their present position being disclosed by means of the narrow crevasses. They were sometimes covered by a thickness of ice of at least six feet. They keep their direction perfectly when beneath the surface. The effect produced is as if a long shallow block of ice had been lifted up, its load of debris deposited in the depression produced, and then the block replaced upon it. No explanation of this occurred to me, and I present it as a curious fact not observed before so far as I know.

The situation and direction of the moraines on this glacier indicate a former flow of the ice from one end of the valley to the other. There are, however, certain difficulties in the way of this view. The material composing the moraines is here of little assistance in determining the question. The mountains adjoining this valley and the neighboring shores of the bay and inlet are all of the same material, and of this the moraines are made up. Occasional large pieces of coarsely crystalline white calcite occur on the moraines. These are supplied from the deposits of calcite found in fissures in the vicinity. I know of none of sufficient size to have furnished these pieces in the mountains adjoining the eastern portion of the valley, and do know of several to the west. This denotes a probability of a former easterly movement of the glacier in this valley. There are many

points of interest in this valley, requiring a careful examination for their elucidation.

GLACIAL DEPOSITS.

Description.—On each side of Muir inlet a deposit of sand and gravel of varying width lies between the water and the mountains —see map. The deposit on the western side is more extensive. It has a width varying from half a mile to a mile, which is greatest opposite Dying glacier valley and diminishes rapidly to the south, having a length of about five miles. That on the eastern side has a width of about half a mile for the first mile of its length and then diminishes to a point, dying out about three miles south of the ice front. For a considerable part of their extent these deposits rise quite abruptly from near the water's edge in steep cliffs with an average hight of one hundred feet. The faces have been chiseled by the rains into very picturesque shapes. They have a talus slope at their base, and are separated from the water by a narrow sand beach. A channel has been cut in each of these deposits by the sub-glacial streams that issue, one from each end of the ice front. The sides of these channels are marked by rough terraces marking occasional local flood plains formed by the streams as they rapidly cut out their channels. These terraces rise rapidly in the direction of the ice and then die out, an effect produced by the retreat of the ice and the consequent shifting of the source of the stream. These deposits possess firmness to a surprising degree, it being in places extremely difficult to make any impression on them with the foot. But their lack of consolidation renders them, especially when water-soaked, an easy prey to running water. They were deposited by swift currents. The material is all coarse, alternating beds of gravel and sand, the gravel largely predominating, and with little or no admixture of clay. Rapid alternations of horizontal and cross bedding characterize them. A considerable number of the pebbles in the gravel are derived from the eruptive rocks far to the north. They have their edges rounded but are much more angular than are stones which have suffered attrition in water for any considerable length of time. They have rather the aspect of somewhat water-worn glacial pebbles.

The altitude reached by these deposits increases as the mountain sides are approached, they having there an elevation of 400

feet. In a steep gully on the side of Mt. Wright they reach a hight of 600 ft.

These deposits overrun by the glacier.—These deposits below the front of the glacier are overlaid by a stratum of varying thickness of true morainic material, rough boulders of varying sizes, few of which show any evidence of attrition, lying on or embedded in a layer of sand and clay. The surface presents numerous "kettle-holes" and kames, its whole configuration being evidently due to a retreating ice sheet. On each side of the inlet the glacier overruns these deposits. (Plate III.) This is best shown on the eastern side, where by passing down the beach to the ice front, a beautiful longitudinal section of the ice lying above the gravels can be seen. The length of this section is a quarter of a mile. At its upper end this ice has a thickness of one hundred feet at least, thence diminishing gradually to an edge. This section is made possible because the wings of the glacier on land, reach further to the south than the seaward portion. On reaching the main front the gravels are seen to pass under the ice, so that their extent in this direction cannot be told. There is something more here than the snout of an advancing glacier riding up over its moraine. This glacier is retreating, and all the evidence shows that it has been doing so for a considerable length of time. That these beds were deposited before the advance of the glacier, from which it is now retreating, took place, is proved by the buried trees shortly to be described. That the present retreat has been long continued, is shown by the condition of the eastern portion of the glacier. A glacier of great thickness has advanced over these gravels, and done so for a considerable time. Much of their original mass has doubtless been removed. But the very considerable remnant is full of significance. The influence of the ice upon it must have been more protective than anything else. At the present time every one of the frequent rains washes down portions of this deposit into the inlet and the rapid, ever shifting sub-glacial streams are constantly undermining its cliffs, so that its mass is being diminished with comparative rapidity.

Origin of these deposits.—These deposits have for their floor an old land surface, with tree stumps still standing in the soil in which they grew, and of which Prof. Wright has written*. Such stumps in situ are exposed on both sides of the inlet, where the

*Ice Age in North America, pp. 57-61.

gravels have been cut away. Those found on the eastern side are along the beach, and are now only exposed at low tide, some being just at low tide level. This floor was a sloping one, rising gently toward the mountains. The deposits on it were laid down by swift currents, and their material had not suffered attrition for any great length of time. Yet it is all considerably rounded and must have been transported some little distance. At least some of it came from the north. From this it follows that these layers of sand and gravel were deposited from the swiftly flowing streams that emerged from the front of the glacier as it advanced toward this spot, aided no doubt, by streams down the mountain sides adjacent, and on the western side from the Dying glacier valley. Subsequently the advancing glacier overran them.

Changes of level in the region.—Prof. Wright explains the thickness of the sand and gravel deposit on the western side of the inlet by the supposition that the Dying glacier would, in its advance, protrude from the end of its valley before the advancing Muir glacier reached that spot, and from a kind of dam, or breakwater, against which these deposits would be built*. This is a pure supposition, there being no evidence that such protrusion would occur first. Nevertheless it might be admitted were it not for the fact that it does not aid in explaining the hight of the gravels on the western side south of Dying glacier valley, nor does it help us at all in accounting for the even greater altitude reached on the eastern side of the inlet. I find myself totally unable to account for the accumulation of deposits of such a character and in such a location to hights of 300 and 400 feet above the surface of the inlet, with the relative levels of sea and land remaining as at present. Should the ice be now removed from the amphitheatre a considerable part of it at least would be covered by sea water, with low sloping shores between the water and the mountains. As the amphitheatre became filled with ice, on the advance of the glacier, it is impossible to conceive of the building up of deposits by the streams of the vicinity to any considerable hight above tide water. The material would have been washed into deep water. But such a deposit could easily have been built up on a slowly subsiding shore. In order to establish such an hypothesis it is necessary to produce evidence of a downward movement of at least from 200 to 300 feet, followed

*Ice Age in North America, pp. 60.

by an elevation of practically equal amount. Evidence of a certain amount of subsidence, and its approximate date is furnished by the tree stumps in situ, already mentioned as occurring on the eastern shore of the inlet at low water mark. As the average tides here have a hight of 20 ft., here is clear proof of a subsidence of at least that amount, and which could not have taken place before the deposition of the gravels. I am however unable to produce further evidence of oscillations of level which have occurred since the deposit was formed, and merely present the idea as provisional, and as the only way occurring to me of accounting for the hight above sea level reached by these gravels. The subsidence indicated by the tree stumps certainly took place during or since the deposition of the gravel deposit, and is shown by evidence shortly to be presented to be very recent.

THE OLD FOREST.

For the most part the mountains of southern Alaska are thickly covered with coniferous trees. The mountains in the vicinity of Glacier bay form a striking exception to this general rule, the shores of the upper part of the bay and the mountains to the north and east as far as the eye can see being without trees. Across the divide to the east, the mountains adjoining Lynn canal are forest covered. Passing down Glacier bay, trees begin to appear on the summits of the mountains on the east side about ten miles distant from the front of Muir glacier. Continuing to the south they become more numerous and extend further down the mountain slopes. The Beardslee islands, and old terminal moraine of the Glacier bay glaciers, near the mouth of the bay, are thickly covered with trees. That the region now bare had its own forests at no distant date is clear. Mingled with the detritus on the sides of the mountains around Muir glacier fragments of old wood are so plentiful that our party never made a camp anywhere without finding plenty of it for fuel within a very short distance. The gravel deposits adjoining Muir inlet are full of it, logs twenty or thirty feet long being not uncommon. Besides these loose pieces are the stumps *in situ* in the old soil upon which the gravel deposits were laid down.* Fragments also occur plentifully on the islands in the bay. All this wood is surprisingly fresh, so that when dry it makes excellent fuel. Sections of it were examined

*See ante. p. 35.

microscopically by Dr. F. H. Herrick of Adelbert College and compared with sections of the more common spruce now growing on the Alaskan mountains, and he pronounces them almost certainly identical.

Destruction of the Forest.—The trees were removed from this region by a recent advance and increase in size of the various glaciers in the vicinity. Those on the low grounds were partially preserved in position by the thickness of soft deposits laid down over them. The old trees appearing on the tops of the mountain ridges ten miles down the bay, mark the point beyond which the ice ceased to cover the tops of these ridges at its period of greatest extent, or at least the point where permanent snow fields ceased, if the main ice stream did not reach this hight.

The bearing of this forest on the history of Muir glacier.—Southern Alaska has all been glaciated. Since the retreat of the glaciers from most of the valleys their slopes have become densely clothed with timber. The evidence just presented seems to necessitate the conclusion that Muir glacier retreated much beyond its present position, and remained in that dwarfed condition at least sufficiently long to permit the growth of a multitude of great trees upon the mountains around Glacier bay and Muir glacier amphitheatre. Then the glacier advanced and destroyed these trees. In this advance it extended down the bay nearly to the Beardslee islands, and in Mine inlet had a thickness at least 2,000 feet greater than at present. From this last advance it is now rapidly retreating. The fresh condition of the old wood, its abundance on the mountains in protected spots, and the distribution of living trees in the lower Glacier bay region, all combine to render it impossible to adopt Prof. Wright's suggestion that this old forest was pre-glacial, in the sense in which he uses it.* It is rather interglacial, and comparatively recent. Muir glacier has not steadily retreated since the great Cordilleran glacier began to vanish, but is now retreating from a comparatively slight advance which followed upon the heels of a great and somewhat prolonged recession. Already young spruces are beginning to shoot up here and there upon the timberless mountains, and it cannot be a matter of many centuries before they will again resume the characteristic Alaskan forest covering. Further evidence of the truth of this view is furnished by a little coral, one of several found attached

*Ice Age in North America.

to the quartz outcrop of the Treadwell mine, and covered by a thin layer of sand and clay. This was brought to my notice by Mr. J. McDonald Calderwood, superintendent of the Treadwell mine, on Douglass island, opposite Juneau. The corals were found about 200′ above tide. Dr. W. H. Dall identifies it as a Paracyathus, agreeing well with the unfigured *P. stearnsii* Verrill, from Monterey. He thinks it improbable that it can exist in the cold Alaskan waters at the present day, though little is known of its distribution, and regards the specimen as probably Pleistocene. The coral became attached to the rocks when the region was depressed at least 200 feet below its present level, and during an apparently somewhat warmer period which followed on the heels of the great glaciation of the region. This agrees well with the evidence furnished by the forest, which also shows at least a small amount of oscillation accompanying the recent small glacial advance.

DISINTEGRATION OF THE ROCKS AROUND MUIR GLACIER.

Its amount.—The rapidity with which the rocks of this vicinity disintegrate is very great. This however is much more true of the slate mountains than of those of limestone or diorite. The fissured condition of the rocks is a powerful aid to the ordinary disintegrating agencies which operate in high latitudes and on high mountains. The piles of debris that have accumulated since the retreat of the glacier are astonishing, considering the shortness of the time that has elapsed. Such masses are already beginning to accumulate, on the surface of the gravels, at the bases of the steep mountain slopes adjoining Muir inlet, although the ice can have retreated from them but a comparatively few years ago. Passing down the bay they increase much in size, and connect with debris streams lying in the gullies. In the Dirt glacier valley the great rapidity of this disintegration is best shown. The practically motionless ice occupying this end of the valley is covered for its full half mile of width with from two to four feet of slaty debris, which increases to a very considerable thickness near the sides of the valley. The larger part of this debris has fallen from the mountain sides, and in a not very great space of time. Such debris is also found to great extent around Pyramid peak. *

* This is in accord with Mr. I. C. Russell's observations in southern Alaska. Bull. Geol. Soc. Am. Vol. I, p. 135.

Débris on glacier-swept mountains.—In general the mountain slopes over which the ice has moved are swept pretty bare of loose material. On the other hand such material is always present to a certain extent. It is largely transported material, left there by the melting ice. Sometimes, as on H, where there is much loose material, it is clearly native and has not been removed. The mountain slopes all around the eastern portion of the amphitheatre are covered with a great amount of such material, extending for a considerable distance below the surface of the ice. Some of this is foreign material left on the slopes of the mountains as the ice decreased in hight, but a considerable proportion has disintegrated since the ice covering has been removed, and is yearly moving down the mountain sides aided by avalanches and spring floods, completely filling the gap slowly forming between the mountains and the ice. This also indicates the inertness of the ice of that portion of the glacier, the melting being more rapid than its slow flow away from its highest point. Even in more rapidly moving portions of the glacier this same phenomenon is manifested, as along the sides of nunatak H, and in the upper portion of the Dirt glacier valley.

Size of moraines on Muir glacier.—This great rapidity of disintegration, and its excessive rapidity in the case of the slates is further indicated by the great size of the moraines on Muir glacier, especially those on the eastern portion. These lie like great embankments on the surface of the ice, are often of very considerable width, and contain an enormous amount of material most of which was supplied by the disintegrating mountain peaks along the sides of the old valley glaciers which supplied the ice now lying here. The whole surface of this portion of the glacier is thinly covered with fine dirt and sand, partially supplied by winds but largely embedded in the ice. The large amount of disintegrated material that must have existed in this basin and which the glacier has removed, together with that constantly supplied during its existence would seem ample to account for the material that the glacier has brought, and is now bringing, down to Glacier bay, judging by the present rate of disintegration. The smaller size of the moraines on the central and western portions of the glacier is readily accounted for. The branches from the west and northwest are adjoined by quartz-diorite mountains which disintegrate much less rapidly than the slates, being fissured less

abundantly and more unequally. In the central part of the glacier most of the morainic material disappears down the crevasses. The effect of the transition from smooth to rough ice on the appearance of the moraines is well shown on those which come down just to the west of H. After a crevasse is formed the sun melts back its north wall rapidly, quickly converting a broad ridge of ice into a very sharp one, changing the appearance of the ridges quickly, and causing most of the moraine load to be dropped. *

Surface Features produced by Muir Glacier. Surface produced on ridges at right angles to the movement.—On all the mountain slopes which Muir glacier has overrun, a tendency toward the production of a surface consisting of small, shallow valleys separated by low ridges is seen, both trending in the direction in which the ice has moved. This configuration of surface is most marked on narrow ridges whose long axes make an angle approaching 90° with the direction of ice movement. Nunatak G, the ridge between the Western branch and the Dying glacier valley, and in a less degree the northerly spurs of Mt. Wright, present excellent examples†. The production of such surfaces in this region depends on the presence and distribution of the fissure planes. Weathering takes place along these planes to varying depths, resulting in the loosening of V shaped blocks of varying sizes. After such decay has been in progress for a considerable length of time, a glacier riding over the ridge and removing loosened material will tend to leave a surface composed of ridge-like projections with shallow depressions between. This will be the more marked the more nearly the trend of the fissures coincides with the direction of the ice. Such a surface could scarcely be produced if the angle between these two was a considerable one. Even without the presence of the fissure planes it is conceivable that there would be a tendency toward the production of such surfaces in regions where rock decay had taken place to varying depths. But no such cause can be assigned here because the rapidity of disintegration prevents decay in place.

Lakes.—On the tops of all the low mountains bordering Muir

* In respect to the size of its moraines Muir glacier seems to be an exception to the generality of Alaskan glaciers that I have myself seen or have seen described. Compare I. C. Russell, Bull U. S. Geol. Sur. Vol. I, p. 151.

†Just such surfaces are figured by John Muir in his paper in the report of the cruise of the Corwin in the Arctic ocean—1885—on the glaciation of the region.

glacier over which the ice has swept, diminutive lakes occur. Two are found on nunatak H, five or six on G, several on the spurs of Mt. Wright, others on the ridges on the western side of the inlet, occasionally one on the islands in the bay. They occupy small depressions or basins on the tops of these ridges. Through a large part of the year these are filled with snow, but in all those observed this snow entirely disappears during summer. Some of these small basins are dry for a part of the summer, but in the case of most of them, either snow or water is found throughout the year. They depend solely on the precipitation for their water supply, and the loss is by evaporation mainly.

They are all very small, only a few yards in diameter and with no great depth. Some of them clearly occupy rock basins, rock in place being readily traced all round them, the proof that ice has filled the basin being furnished by the striæ which run in at one end and out at the other. Other lakes have a portion of their shores formed of glacial debris. The conclusion cannot be avoided that these hollows were the work of ice. In most cases the method of their formation seems clear. They mainly lie in the small valleys on the mountain ridges, whose origin has been referred to,* occupying the most depressed parts of those valleys. The ice moving down this slope must have impinged with great force at the bottom, tending to the production of a hollow, especially if aided by a somewhat greater amount of loosening of the blocks than usual. The sides of these valleys are not planed smooth by the ice, but present surfaces of considerable roughness.

The rough edges have uniformly been somewhat smoothed, but the character of the surfaces seems to me to clearly show that the valleys and the basins have been formed by the removal of loosened blocks, leaving a rough jagged surface whose edges have been smoothed and polished.

The islands in Glacier bay.—Several low islands project from the waters of Glacier bay, two of them occuring in Muir inlet. Upon them all, the two in Muir inlet especially, the ice must have exerted great force, for they lie directly in its path at a time when it was hemmed in between high rocky walls. Moreover the ice, in Muir inlet at least, had just passed from a wide amphitheatre into a narrow valley, in which last it must have moved with considerably accelerated velocity. As a natural result the rocky

*See ante.

walls of this gap and the low crags occurring in it as islands are smoothed, polished and striated in a high degree. On the islands especially, beautiful examples of striæ occur, following every little irregularity which the sides present. Striæ ascend and descend, both straight and obliquely; curve in various ways and in various planes; occur on the lower side of overhanging surfaces; not uncommonly produce beveled edges. The ice evidently fitted itself to them like a glove. This local character of the striæ on the mountains, in or adjoining the path of the ice is a noteworthy feature throughout this region, and very important in its bearing on the nature of the movement of glacial ice, close to the bottom and sides of its valley, showing a great complexity of movements depending on the configuration of the surface. Often the most insignificant obstacles suffice to cause a change in the direction of the striæ. The finest example of striation in the region is furnished by the small limestone island in Glacier bay on which fossils were found. The whole island is covered from end to end with the freshest and prettiest striæ one could wish to see, and examples are furnished of nearly all the variations that striæ can exhibit.

The gravels along Muir inlet.—These gravels have been described in a previous part of this paper, with mention of the fact that the ice overruns them, and of the evidence that it formerly did so in great mass and for a considerable lapse of time.

These deposits are essentially unprotected and lie in the narrowest part of the narrow gap in which the ice must have exerted its greatest force. Yet in the last advance of the glacier over this spot a considerable thickness of these unconsolidated deposits was not removed. †

Old surface features not obliterated.—On the mountains in Muir glacier basin from which the ice has recently retreated, surface features are occasionally observable which seem incompatible with the theory that glaciers vigorously erode hard rock. For example on the east side of H, along and over which ice of great thickness must have moved, a gully exists running down the side directly at right angles to the direction in which the glacier is moving. This gully has no great width nor depth. It is inconceivable that ice moving along the sides of such a mountain should cut out a gully of the kind running down the mountain directly at right

† See G. F. Wright. Ice age in North America, p. 203.

LAKE
Granite Cañon
Girdled Glacier
BERG LAKE
Glacier 8
Glacier 9
Main Valley
Tree Mt.
LAKE
MAIN
Mt. Young
Eastern Branch
White Glacier
Glacier
Scale of Miles
0 1 2 3 4 5
MUIR GL
26'

angles to the movement of the ice. On the contrary had the glacier been vigorously eroding the mountain side its tendency would have been to obliterate the gully by grinding down the sides to an equality with it. That the gully was filled with ice moving along it and at right angles to the motion of the main mass is shown by the perfectly preserved striæ in the gully having that direction, while the striæ on the mountain sides close at hand have the direction of the main movement. Granting the erosive power of glacial ice, the slow moving tongue of ice in the gully could have had little erosive power compared with the great mass sweeping over it along the side. Hence the erosion should have caused its disappearance. That the glacier has done little more than to remove the loosened rock and polish the resulting surface is shown in a vast number of localities here by the character of that surface. Where the ice has been forced through a narrow gap the sides of that gap are planed to a pretty smooth surface. Where it has run against an obstruction in its path it has pretty thoroughly polished the *stoss* side. Otherwise the surface presented is a somewhat jagged one with the rough edges polished but not much planed down, showing that after the loose, fissured material was removed, leaving a somewhat pitted surface, the ice was even unable to obliterate the traces of the cavities from which the last blocks were removed. This naturally is more especially true of the harder eruptives than of the softer rocks, and such surfaces are well shown on G and H.

Sediment brought down by streams.—Estimates of the amount of material brought down by the glacier are difficult to obtain owing to the fact that the material is all carried into the sea, that the number of sub-glacial streams is not known, and that there is no evidence that those which issue from the ice directly into the water carry as much sediment as those which issue from the corners and flow through the gravels. I could find no evidence inconsistent with the supposition that the debris falling on the surface of the ice yearly, together with the previously disintegrated material which the ice has removed and is removing is amply sufficient to account for all the detritus deposited at the front of the glacier. The amount of material in sight on the surface of the glacier is enormous.

Rock basins. The manner of occurrence of the small rock basins found in the district has already been given, together with

the evidence that they have been scooped out by the ice. Even this however, at least in the case of all which I saw, does not seem to me to necessitate the theory of the great erosive power of ice. All these basins which I saw lie in small valleys on the mountain tops whose presence seemed to depend on the fissure systems and on the varying depths to which loosening of blocks had taken place. They lie at the foot of slopes down which the ice moved impinging with unusual force at its base, where the greatest amount of polishing and striating has taken place.

Those who hold the power of glaciers to vigorously erode hard rock under most circumstances it seems to me take an indefensible position. At Muir glacier, in just the position where the greatest erosion would naturally be expected, soft gravels have been undisturbed by the ice. The key setting forth when glaciers will erode and when not, is certainly lacking at present.

It is very advisable that a prolonged and detailed study of Muir glacier should be undertaken. It is a comparatively large glacier rapidly dying out, and presents an admirable opportunity for studying the behavior of a large glacier under such circumstances. Such work could not fail to prove of great value.

PLEISTOCENE PAPERS AT THE WASHINGTON MEETINGS.

The following brief notes of papers treating of the Pleistocene or Glacial period are arranged in the order of their presentation before the three successive scientific meetings in Washington, D. C., August 17th to September 1st, 1891.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION E. GEOLOGY AND GEOGRAPHY.

Source of supply to lateral and medial moraines. By JOHN T. CAMPBELL. A short paper, describing moraines in Indiana.

Postglacial anticlinal ridges near Ripley and Caledonia, New York. By G. K. GILBERT. In Ripley, the most western township of New York bordering lake Erie, a cliff of Devonian shale forming the lake shore displays a small anticlinal disturbance of the beds, which at the surface are raised in a ridge six or eight feet high. This disturbance extends down in gradually diminishing amount through the 40 feet to the lake level, but apparently not much lower. Like other small ridges of Devonian shale in

northwestern Ohio, and of Trenton limestone in northern New York, they are shown to have been formed after the departure of the last ice-sheet, and are attributed to the postglacial rise of temperature and consequent expansion of the rocks.

Another locality of somewhat similar phenomena is at Lime Rock, close west of Caledonia and near the east line of LeRoy, Genesee county, N. Y. A great number of small anticlinal ridges there seen are postglacial, but they differ in type and probably in origin from the foregoing. They are mainly parallel with each other and with the strike of the strata, and the anticlinals are usually unsymmetric and much fractured. The surface rock is Corniferous limestone, underlain by Salina shales, in which a few miles northward the drill has discovered a bed of salt. Strongly saline springs show that here salt and gypsum are being removed from the shales somewhat rapidly by underground drainage, and Mr. Gilbert concludes that the overlying limestone sinks in large masses, and that the ridges are the superficial phenomena of the partings of these blocks.

In the discussion of this paper, Prof. E. W. Claypole spoke of the irregular sinking of the surface in the salt mining district of Cheshire, England, whereby buildings and chimneys are caused to lean and fall if not rebuilt.

Processes of mountain-building and their relationship to the earth's contraction. By Warren Upham. The concluding part of this paper pointed out the evidences of unusual activity of the forces which produce folding of mountain ranges, eruption of lavas, and epirogenic uplifts and subsidences, during the Pleistocene period, in comparison with previous geologic time since the end of the Palæozoic era. To this Pleistocene or Glacial period belong much plication and uplifting of the Coast range, of the St. Elias range, of the Sierra Nevada, Wahsatch, and other Basin ranges, and much of the grand outpouring of lavas from Lassen Peak and Mt. Shasta northward along the Cascade range and eastward to the Yellowstone National Park.

In the ensuing discussion, Prof. Joseph Le Conte referred to the proofs of great Pleistocene uplifts of North America, shown by river channels submerged by the sea to depths of 2,000 to 3,000 feet on both the Atlantic and Pacific coasts.

On the cranial characters of Equus excelsus Leidy. By E. D. Cope. Exhibition of the skull of an extinct horse from the

Equus beds of western Texas, with which stone implements are also found, embedded in the same stratum. This skull was broken in upon the forehead, as if by a rounded stone used as a weapon; and it was suggested that the prehistoric extinction of the genus Equus on this continent, as also of other large Pleistocene animals, may have resulted from their chase and slaughter for food by the contemporaneous savage tribes of men.

Exhibition of certain bones of Megalonyx not before known. By JAMES M. SAFFORD. The bones were recently found embedded in earth on the floor of Big Bone cave, in eastern Tennesee. They include the pelvis, and supplement the collection of Megalonyx bones long ago found in the same cave and described by Leidy. It is therefore likely that the two collections represent the same individual. The lateness of extinction of this animal is indicated by portions of the cartilage of the joints still adhering to the bones.

Prof. E. D. COPE, in discussion, stated that Megalonyx appears to have been an exclusively North American genus.

On the probable existence of a second driftless area in the Missippi basin. By R. D. SALISBURY. This area lies in the space between the Mississippi and the Illinois river near the mouth of the latter stream, and is comprised in Calhoun county and the southern part of Pike county, Illinois. Its extent is perhaps 500 square miles. Hundreds of good sections observed on the high summit plain of this area and at heads of its ravines show no glacial drift or till. On its borders the drift is attenuated, like the tracts of the early drift sheet bordering the Wisconsin driftless area. The topographic features of castellated rock cliffs and pinnacles are similar in both these areas. The surface of this smaller driftless area is mostly loess, from 15 to 50 or 60 feet in thickness; and this is often seen to rest conformably on a gravel and sand deposit, which may be the representative of the Lafayette formation or Orange Sands.

The Cincinnati ice dam. By FRANK LEVERETT. Examination of the Ohio valley during this summer shows that fine silt overlies the till along the valley both above and below Cincinnati. This silt constitutes a continuous formation, and must be ascribed to deposition during a time of very gentle drainage subsequent to the retreat of the ice-sheet from its extreme limit, which crosses the Ohio river into Kentucky as traced by Prof. G.

F. Wright. The ice dam which Wright and others supposed to have turned the Ohio temporarily out of its valley, so as to flow around the ice-front, producing a lake above Cincinnati, was not the cause of this silt deposit, nor of the conspicuous terraces of the Ohio, Monongahela, and Allegheny rivers, which are of fluvial origin, sloping in the same directions as the present streams.

Prof. J. W. SPENCER, in discussion, stated his belief that depression of the land to the sea level accounts for the silts of these valleys and for the Pleistocene shore lines about the great lakes tributary to the St. Lawrence.

President T. C. CHAMBERLIN replied that in basins sloping northward the receding ice-sheet, pausing at many stages which are marked by moraines, was a barrier holding these lakes at the higher levels of their ancient beaches.

The attitude of the eastern and central portions of the United States during the Glacial period. By T. C. CHAMBERLIN. The deposition of loess in the lower Mississippi valley was contemporaneous with the maximum extension of the ice-sheet in this basin, during the earlier great epoch of glaciation. The attitude of the land was then low, with very slack drainage, allowing this fine silt to be spread by broad river floods or in shallow lakes. A long interglacial epoch followed, in which the Mississippi basin was moderately uplifted, with increasing amount toward the north. Great erosion of the loess and of the underlying gravel and sand, formerly called Orange Sand but now named the Lafayette formation, took place during this interglacial time. The waters flowing from the ice-sheet and terminal moraines of the later glaciation carried much gravel, sand, and fine silt into the channels of tributaries of the Mississippi, and along the broad, deeply eroded valley of this river, showing conditions of drainage similar to those of the present time. On the Atlantic coast marine clays overlying the till in southern Maine, along the St. Lawrence, and in the basin of lake Champlain, proved that during the maximum advance of the ice-sheet and its recession the land was depressed somewhat lower than now. President Chamberlin therefore concludes that the Ice age was not attended by any high elevation of these regions. [See this paper in the Nov. GEOLOGIST.]

Mr. WARREN UPHAM, in discussion, noticed that this paper treated only of the closing part of the epochs of glaciation, when

the ice attained its farthest limits and especially when it was rapidly retreating. He thought that the view presented first by Dana, in his address as retiring president of this Association in 1855, is more probable, namely, that a great elevation of the country, shown by fjords and deeply submerged valleys, attended and caused the ice accumulation; that the time of departure of the ice was one of depression, which we now recognize to be due to the vast pressure of the ice itself; and that there has been a partial re-elevation since the Glacial period.

Neocene and Pleistocene continent movements. W J McGee. Changes in the relative hights of land and sea on the coastal plain of the southern Atlantic states during the later part of the Tertiary era and in the Pleistocene period are shown by the Chesapeake, Lafayette (formerly called Appomattox), and Columbia formations. The Chesapeake formation, consisting of fine sands and clay, of Miocene age as known by its fossils, was deposited during a marine submergence of the coastal plain and edge of the hilly Piedmont belt. After an interval of moderate uplift and erosion, the next overlying Lafayette formation, considered provisionally as Pliocene, was deposited, consisting of gravels, sands, and fine loams. These are referred to marine sedimentation of the tribute brought by inflowing rivers from the adjacent Piedmont and Appalachian belts, the amount of submergence below the present sea level being several hundred feet. No fossils, however, are found in this formation. Directly following the time of the Lafayette deposition, a prolonged stage of high land elevation is shown by deep channelling of the Lafayette beds, and by great erosion of gorges in the hilly and mountainous belts on the west. The next epoch of deposition is the Columbia, correlated with the earlier glacial epoch, when gravels, sand, clay and loam, destitute of fossils and enclosing occasional ice-floated boulders, were deposited along the river valleys and over considerable areas of the coastal plain. This formation is regarded as evidence of estuarine and marine submergence, decreasing from a depth of fully 400 feet in the latitude of New York to 150 feet at Washington and perhaps 75 feet in the latitude of Cape Hatteras, but thence increasing to about 700 feet on the Savannah, again diminishing to less than 50 feet at Mobile bay, and again increasing farther westward and northwestward. The Columbia deposition, like the Lafayette, was immediately

followed by a stage of greater elevation than now, with active erosion.

Prof. E. W. HILGARD, in discussion, described the cross-bedding or "flow and plunge structure" of the Lafayette formation along the Mississippi valley, attributing it to fluvial instead of marine deposition. The size of its pebbles on the lower Mississippi indicates for the river during the Lafayette epoch a gradient which would place the northern portion of its basin probably 3,000 feet higher than now.

Prof. C. H. HITCHCOCK referred to the marine beds of Maine, the St. Lawrence, and lake Champlain, enclosing arctic species of shells, as proof of subsidence of that region while the climate of the Glacial period still lingered there.

Mr. UPHAM regarded the Lafayette and Columbia formations as fluvial deposits spread upon the coastal plain during epochs of plateau-like high altitude, and correlated these formations respectively with the first and second great glacial epochs. Before each of these stages of continental elevation, the Piedmont and Appalachian regions had long lain at lower altitudes, and their surface was largely occupied by residual clays and by alluvial sand and gravel. With the elevation of the region, increased rainfall and snowfall and resulting river floods swept away these superficial materials from the mountain valleys and spread them on the plain, where the streams expanded over broad areas with shallow and slackened currents. When soon the supply of material decreased, the streams cut deeply into this plain. The Indo-Gangetic plain, south of the Himalayas, was cited as an analogous fluvial formation of vast extent and rising from the sea level to an altitude of more than 900 feet.

A study of the fossil avifauna of the Silver Lake region, Oregon. By R. W. SHUFELDT. Many bones of birds are found in the Equus beds of this district. About fifty species of birds are determined, of which fifteen or sixteen are extinct, the proportion being nearly the same as of the associated mammalia. Nearly all are water birds, but the prairie hen was also abundant. Among the extinct species are a flamingo, a heron, a raven, and a blackbird.

The highest old shore line on Mackinac island. By F. B. TAYLOR. Five well-marked beach ridges of gravel and sand are found on this island, adjoining the strait between lakes Huron

and Michigan, at hights from 170 to 205 feet above the level of the lakes and strait. Proceeding thence about forty miles southwestward to Petoskey, the highest of these beaches gradually declines to about 100 feet, having a gradient of 2½ feet per mile; but beyond Petoskey it falls only six inches per mile. Higher shore lines are found on the mainland, but not on this island, which attains an altitude of about 300 feet.

Striæ and Slickensides at Alton, Illinois. By J. E. TODD. Descriptions of superficial striæ, and of slickensided rocks exposed by quarrying. The two were regarded by the speaker as of similar origin, and therefore not indicative of ice action; but Prof. Salisbury and Mr. Leverett, who had also seen these striæ, confidently regard them as glacial marks. They are situated within the drift-bearing area, near its boundary.

GEOLOGICAL SOCIETY OF AMERICA.

On the Quaternary changes of level in Scandinavia. By Baron GERARD DE GEER, of Stockholm, Sweden. Fossiliferous marine beds and former shore lines, overlying the till, occur in Sweden and Norway, increasing in hight toward the interior of the country. The greatest elevation at which they have been found is 800 feet, and a continuation of their gradient to the axial area of the Scandinavian ice-sheet would imply a maximum depression of the land there to a depth of fully 1,000 feet. At the time of this occupancy of the lower portions of the country by the sea, not more than one two-hundredth part of the ice remained still unmelted. In places shallow straits stretched across southern Sweden, but the enlarged Baltic sea on the east side of this peninsula was only brackish, lacking much of the saltness of the ocean. After this submergence, the land was uplifted somewhat higher than now, perhaps as much as 100 feet; and the climate or at least the temperature of the sea was warmer than now, as is shown by southern species of shells in the kjökken-möddings. Another depression of the land ensued during the early part of the Neolithic age, when there was a marine submergence to the extent of 100 feet at Stockholm and about 200 feet in some other parts of southeastern Sweden. The first and greater depression closely attended the latest glaciation, and in some places reached its maximum after the retreat of the ice; and the second

depression, within Neolithic time, was probably only a few thousand years ago.

Muir glacier and its vicinity. By H. P. CUSHING. An interesting description, with lantern illustrations. The rate of glacial motion near the border, according to Mr. Cushing's measurements, is four to eight feet per day, being much less than the rate determined by Wright for the more central portions of this famous Alaskan glacier. [See this paper, p. 207.]

The present standing of the several hypotheses of the cause of the Glacial period. By THOMAS C. CHAMBERLIN. The restriction of the great areas of Pleistocene glaciation to one side of the northern hemisphere forbids our receiving the ingenious astronomic theory of the late Dr. Croll as an adequate explanation of the causes of the Ice age. Also, from the line of argument employed by the speaker in his previous paper before the American Association, the theory of high uplifting of the land to account for the ice accumulation seems equally untenable. An elevation of 10,000 or 15,000 feet would probably be required, and this great uplifting must be shown to have been contemporaneous and co-extensive with the glaciation. Therefore, finding no evidence of such continental elevation, the most probable theory is believed to be that of changes in the position of the earth's axis and its poles, bringing the glaciated countries into high latitudes with arctic climate. A paper presented before the astronomic section of the American Association at this meeting by Prof. George C. Comstock, on "The secular variation of terrestrial latitudes," shows that a slow change in the place of the north pole is now in progress and has amounted to four and a half seconds during the past century. Such movement of the pole may have been more rapid during the Glacial period. If the north pole were transferred fifteen or twenty degrees toward the south end of Greenland, the drift-covered areas of North America and Europe would be brought into latitudes favorable for their envelopment by ice.

Prof. C. H. HITCHCOCK, in discussion, suggested that the sun's heat may have been variable, being considerably diminished during the glacial epochs.

Prof. N. S. SHALER distrusted the explanation by movement of the earth's axis, and inclined instead to believe that geographic changes during the Glacial period induced cool and humid cli-

mates, with abundant snowfall but not excessive cold, where the ice-sheets were accumulated.

Mr. WARREN UPHAM referred to recent calculations by Prof. T. G. Bonney, that a decrease of about fifteen degrees in the mean temperature of Europe and North America might reinstate a glacial epoch. For this change, according to observations of mean temperature as dependent on altitude, an elevation of 5,000 feet, or probably even of 3,000 feet, would suffice. Fjords of Arctic and northern shores of all glaciated regions, the continuation of the Hudson valley to a depth of 2,800 feet below the sea level, and equally deep submerged valleys on the coast of California, demonstrated by Le Conte to belong to the Pleistocene period, show that the unique Ice age was closely attended by a very remarkable epirogenic uplifting of this continent. Two so wonderful geologic episodes probably sustained causal relations to each other, the great elevation being the cause of cool climate and ice accumulation. Such geographic changes seem also more likely to come on rapidly, to cease by ensuing depression, and afterward to be renewed, than would seem possible for changes of the poles. The present rate of change of the north pole is about 450 feet during a hundred years, but the distance that it should be removed to produce each glacial epoch of the two or more recognized within the Pleistocene period is 1,000 or 1,500 miles.

On the northward and eastward extension of Pre-Pleistocene gravels in the basin of the Mississippi. By R. D. SALISBURY. The Lafayette formation is found to extend beneath the glacial drift in western Illinois about 100 miles northward from the drift boundary, to the vicinity of Keokuk, Iowa. Farther to the north, at Rock Island, the same formation is known to have existed, for pebbles of its gravel occur in the drift. Some of the gravels of the driftless area in Wisconsin are probably also of Lafayette age. In the Ohio basin the Lafayette gravel contributed to the drift as far eastward as the southeast corner of Indiana.

On certain extra-morainic drift phenomena of New Jersey. By R. D. SALISBURY. Deposits of undoubted till have been discovered five to twenty miles south of the terminal moraine which was mapped about fourteen years ago across northern New Jersey, and which has since been supposed to be the extreme limit of glacial action. The boulders and smaller rock fragments of this

till are much decayed and colored by oxidation of their iron. A large proportion of them yet show glacial striation, and this is notably true of the occasional masses of soft shale, which could not endure water transportation. In one place the till lies on a highland 300 feet above the moraine, which is there three miles distant to the north. The thickness of this extra-morainic till ranges from 30 to 70 feet, as shown by sections and wells. Judging from the contrast in their degrees of oxidation, this till appears to be surely ten times and quite probably fifty times older than the moraine.

Inequality of distribution of the englacial drift. By WARREN UPHAM. The detritus which was contained within the ice-sheet, called englacial drift by president Chamberlin, is very unequally distributed. Tracts in New England, New York, Minnesota, and Manitoba, were described, some of them notable for the abundance and others for the scantiness of the englacial drift. Its amount or average thickness held within the ice at the time of its final melting and then exposed on the ice surface, as on the present Malaspina glacier at the foot of the St. Elias range, is estimated to have varied, in the northern United States and in Manitoba, from almost nothing to about forty feet. The relationship of the englacial drift to the terminal moraines, and the forms in which it was deposited during the departure of the ice, namely, as englacial till, perched blocks, kames, osars or eskers, valley drift, loess, and deltas of glacial lakes or of the sea, were briefly noticed.

Defloration and deformation of alluvial deposits in New England. By HOMER T. FULLER. Effects of drought and winds on sandy river terraces, producing dunes since the clearing of the original forest, were described; and the speaker recommended the re-foresting of many of these tracts.

On a deep boring near Akron, Ohio, and its significance. By E. W. CLAYPOLE. A preglacial or interglacial channel of the Cuyahoga river in the south part of Akron, now filled with silt, has a depth of 390 feet. In another channel somewhat farther east and tributary to the foregoing, a boring this summer passed through about 150 feet of gravel, in which, near the underlying rock-bed, a stone arrow-point was found.

INTERNATIONAL GEOLOGICAL CONGRESS.

The second day of the Congress was devoted wholly to discus-

sion of the classification of Pleistocene formations. President CHAMBERLIN opened the discussion by remarking that it is possible to classify these deposits upon three bases: 1. Structural; 2. Chronological; 3. Genetic. He then presented, in printed form, a "Proposed genetic classification of Pleistocene glacial formations." The general classes were noted as follows:—

I. Formations produced by direct action of Pleistocene glaciers.

II. Formations produced by the combined action of Pleistocene glaciers and accompanying glacial drainage.

III. Formations produced by glacial waters after their issuance from Pleistocene glaciers.

IV. Formations produced by floating ice derived from Pleistocene glaciers.

V. Formations produced by shore ice and ice floes due to low Pleistocene temperature, but independent of glacier action.

?VI. Formations produced by winds acting on Pleistocene glacial and glacio-fluvial deposits under the peculiar conditions of glaciation.

The first class includes (1) subglacial till, drumlins, and submarginal or lodge moraines, these being products formed at the base of the glaciers; (2) dump moraines, englacial till, and medial moraines, these being products derived from material borne on the glaciers and within them; and (3) push moraines, and lateral moraines, these being products of the mechanical action of the edge of the ice.

Under the second class are osars, kames, overwash aprons, and other tracts of assorted drift.

The third class comprises valley drift, loess, and deltas formed in lakes or the sea.

The type of the fourth class is glacio-natant till, which is supposed to be deposited in glacier-fringing lakes or in the ocean.

In the fifth class are various shore ridges, littoral deposits, and off shore deposits.

To the sixth class dunes and eolian loess may be referred.

In discussion of this scheme of classification, Prof. ALBERT GAUDRY spoke of the Quaternary faunas of the Paris basin, of England, Germany, and Italy, some of which imply cold and others warm climatic conditions.

Prof. H. CREDNER and Baron DE GEER approved the foregoing

classification; but the latter would distinguish the marine deposits as a separate class.

Prof. T. McKenny Hughes explained the abundance of striated boulders in one part of the glacial deposits and their absence in another. If the supply of material (that is, of rock masses projecting above the ice) ceases at any point, then all the boulders will gradually sink through the ice and become glaciated at the bottom. He thought it advantageous to distinguish long gravel ridges by the name osars, and short ridges and knolls as kames. He expressed his opinion that the Ice age was a single continuous cold period, in England at least, except for slight and unimportant oscillations in the extent of the ice-sheet. It was probably introduced by a stage of very high land elevation.

Dr. F. Wahnschaffe preferred a chronological classification. In northern Germany the ground-moraines of two distinct glacial epochs are separated by fossiliferous sand and gravel of interglacial age.

Prof. H. Credner thought these stratified beds between deposits of till to be merely local, indicating some retreat and readvance of the ice-sheet but no interglacial epoch.

Prof. A. Pavlow urged the need of a more satisfactory definition of the Pleistocene period.

Baron de Geer recognized two glacial epochs in Sweden, due to two great oscillations. These cannot always be separated, as, for instance, in Russia. For this reason it is best to commence with a genetic classification, since this causes less confusion to the field geologist.

Dr. Wahnschaffe replied to Prof. Credner's assertion that there is no proof of an interglacial epoch in northern Germany. He thought that the existence of a diluvial fauna between the two tills is sufficient proof.

Prof. Credner replied that no complete skeleton has been found, but only single bones which may have been transported and deposited with the gravel.

Dr. Wahnschaffe again replied that the bones occurring in these gravels are proportionately large, when compared with the gravels, and therefore cannot well have been transported from a distance.

Prof. N. S. Shaler stated that organic deposits may occur

very near the ice-sheet, which allows an interweaving of organic and glacial deposits.

Mr. G. K. GILBERT remarked that in Alaska, according to Mr. I. C. Russell's observations, the waning ice-sheet becomes covered with drift and even with a growing forest, in which bears and other animals live.

Dr. CARL DIENER suggested that intercalated beds of sand are no positive proof of interglacial epochs. In the Austrian Alps moraines no more than twenty years old are covered with pasture, and in the Caucasus the rhododendron grows to the very edge of the ice.

Dr. N. O. HOLST mentioned two moraines separated by interpolated sand, and thought that they might both have been formed by the same ice-sheet. The melting of the ice leaves an unoxidized (blue) ground-moraine, with an overlying oxidized (yellow) upper moraine. This also occurs in northern Sweden, where there is no indication of a retreat of the ice.

Baron DE GEER could not understand the occurrence of thirty or forty feet of stratified sand between two moraines of the same glacial epoch. The colors are sometimes the reverse of what has been stated by Dr. Holst, and the boulders in the two moraines have been derived from different sources.

Mr. JAMES C. CHRISTIE described the section of peat and silt between two layers of till, occurring on the river Clyde above Glasgow.

Mr. HENRY M. CADELL reported five distinct layers of till occurring in a preglacial river channel in eastern Scotland; and also mentioned another river channel, filled with coarse gravel derived from rocks occurring farther north in Scotland, which was covered with a later layer of boulder clay.

Mr. W J McGEE mentioned the importance of land forms in interpreting geologic processes. Any primary geologic classification must be genetic, but he preferred a comprehensive scheme of classification of all Pleistocene formations, whether of glacial or other origin, making thus five classes: A. Aqueous; B. Glacial; C. Aqueo-glacial; D. Eolic; and E. Volcanic.

President CHAMBERLIN, in closing the discussion, said that there is great difficulty in applying a chronologic classification, and that such a classification may even act as a barrier to observation and to the recognition of the truth. Chronologic classification is the ultimate goal of glacial studies, but it is something for which we are not as yet prepared. Red, oxidized subsoils are

not developed in northern latitudes. Organic deposits between glacial layers are abundant in the West, but do not belong to a single horizon. Many facts of erosion and physical geology indicate that the Glacial period in America was widely differentiated and of long duration. How many distinct epochs it embraced we do not as yet know.

Prof. E. D. COPE asked leave to add a remark concerning Pleistocene palæontology. An abundant tropical fauna is found in the Equus beds. If these are of interglacial age, there is indicated for that time a very warm climate. This fauna is succeeded by a truly boreal fauna. These may become the basis of a chronologic subdivision of Pleistocene deposits.

Dr. HANS REUSCH, of the Geological Survey of Norway, exhibited slabs of sandstone bearing Palæozoic glacial striæ and furrows, from the Varanger fjord (noticed in the AM. GEOLOGIST, vol. VII, p. 388, June, 1891).

During the afternoon of a later day of the Congress, some of the geologic features of the country to be traversed by the western excursion, which started immediately after the adjournment, were described. The Pleistocene topics were the following: President CHAMBERLIN, on the series of terminal moraines, the driftless area of Wisconsin, the recession of the falls of St. Anthony, the glacial lake Agassiz, etc., and Mr. GILBERT, on lake Bonneville, whose area will be entered by the railway excursion party through Cache valley, the old outlet of that lake, and on the recession of the falls of Niagara, which will be visited after returning from the Far West.

Under the courteous guidance of Mr. N. H. DARTON, of the United States Geological Survey, many of the members of the Congress examined sections of the Potomac, Severn, Pamunkey, Chesapeake, Lafayette, and Columbia formations in Washington and its vicinity and along the lower course of the Potomac river or estuary.

EDITORIAL COMMENT.

THE INTERNATIONAL CONGRESS OF GEOLOGISTS. WASHINGTON MEETING.

The late session of the International Congress, while an important event which will bear fruit in the near future conducive to the progress of the science of geology, cannot be said to take equal rank with those which have preceded it. It afforded great

pleasure to numerous American geologists to meet the continental geologists of Europe, with whose work they had become familiar, but whose faces they had never seen, and to grasp by the hand some of those whom they had previously known only through the exchanges of formal correspondence. But the English-speaking American, while heartily welcoming the small number of geologists present from Great Britian, was much disappointed that the meeting was largely ignored by the body of English geologists. He was still more surprised that his English-speaking cousin, who dominates the American continent from the great lakes to the northern pole, should have but two nominal representatives. Not one official geologist of either Great Britain or Canada attended the congress. This anomalous and significant fact may be susceptible of an explanation which will not implicate any one in any unpleasant manner, but at the present time it bears the *prima facie* evidence of some common cause, by reason of which our nearest allies preferred to express their sense of disapproval by dignified non-attendance.

From Germany there was a large delegation—twenty-three geologists—, from Mexico three, from Peru one, Roumania two (each accompanied by his wife), from Russia eight, (Prof. Pavlow also had his wife with him), from Sweden four, Norway one, Belgium three, Switzerland two, Austria-Hungary three, Chili one, and from France five. From the United States one hundred and forty-eight were registered (including ladies), of whom fifty-three are connected with the United States Geological Survey. Ten active "state geologists" were present, and other state surveys (Michigan and Kentucky) were represented by geologists employed thereon. From New York city six attended, and from other parts of New York state eleven. From Philadelphia came six, and from other parts of Pennsylvania three. There were four from Baltimore, and none from other parts of Maryland. New Hampshire and Vermont each sent one. Massachusetts sent fourteen, Connecticut four, and Rhode Island two. There was one present from New Jersey, one from Virginia, and one from West Virginia. Two registered from North Carolina, and one from South Carolina. There was one each from Florida, Georgia, Arizona and Alabama, and three came from Texas. From Arkansas three were present, from Missouri five, from Colorado, S. Dakota, Kansas and Nebraska one each, and from California four. Ohio sent

six, Indiana and Minnesota each one, and Iowa and Illinois five and four respectively. Michigan had three representatives, Kentucky one and Tennessee one, and Wisconsin four. From the District of Columbia there were sixty-three members of the congress.

The congress was organized by the election of the following:—

BUREAU.

Présidents d' honneur.

James Hall. James D. Dana.

President.

J. S. Newberry.

Vice Présidents.

ALLEMANGE—K. von Zittel and H. Credner.
ANGLETERRE—T. McK. Hughes. AUTRICHE—E. Tietze.
AUSTRALIE—Arch. Liversidge. BELGIQUE—E. Van der Broeck.
CANADA—J. C. K. Laflamme, Thos. Macfarlane.
CHILI—F. I. San Roman. HONGRIE—Joseph von Szabó.
DANEMARK—F. Johnstrup. INDES—F. R. Mallet.
ECOSSE—H. M. Cadell. IRLANDE—A. Sollas.
ESPAGNE—M. F. de Castro. ITALIE—G. Uzielli.
FRANCE—A. Gaudry, Chas. Barrois. MEXIQUE—A. del Castillo.
NOUVELLE ZELANDE—F. Hutton. NORVEGE—H. Reusch.
PORTUGAL—J. F. N. Delgado. SUEDE—Gerard de Geer.
ROUMANIE—G. Stefanescu. SUISSE—H. Golliez.
RUSSIE—Th. Tschernyschew, F. Schmidt, A. Pavlow. ETATS-UNIS—Joseph Le Conte, J. W. Powell, Raphael Pumpelly.

Secrétaires generaux.

H. S. Williams, S. F. Emmons.

Secrétaires.

J. C. Branner, G. H. Williams, C. Diener, Emm. de Margerie, F. Frech, Whitman Cross.

Trésorier.

Arnold Hague.

The following abstract of the proceedings of the congress is taken from the daily printed record kept by the secretaries, and is "subject to revision."

SESSION OF AUG. 27, 1891, 11.40 A. M.

Prof. Joseph Le Conte, Vice-President, in the chair.

As there were no reports of committees, the discussion on the classification of Pleistocene deposits was at once entered upon.

Prof. T. C. Chamberlin opened the discussion by remarking that it was possible to classify these deposits upon three bases: 1. Structural; 2, Chronological; 3. Genetic.

A scheme of classification according to genesis was offered to the Congress in printed form and explained at length.

Prof. Gaudry spoke as follows: In the Parisian basin there are two different horizons distinguished by different faunas; the one indicating a cold, the other a warm climate. It is, however, impossible to decide which of these two periods was the earlier. In England the same condition of affairs is to be observed. In Germany there is but one Quaternary fauna, which indicates a cold climate, whilst in Italy the fauna of the cold period is absent.

Prof. H. Credner: The north German plain contains deposits closely related to those of the Pleistocene in America. Prof. Chamberlin's classification is admirable and wholly applicable to Germany.

Baron de Geer expressed his approbation of the classification proposed by Prof. Chamberlin. He had for some years been advocating a similar classification for Scandinavia. A few minor alterations might be suggested to suit Scandinavian conditions; for instance, the marine deposits might be made a separate class; classes IV and V of Prof. Chamberlin could, perhaps, be reduced to sub-classes under III, as the formations frequently seem to be accidental or local. He agreed with the distinction suggested between osars and kames; that is, that the former are in the main radial and the latter peripheral with reference to the distribution of land-ice.

Prof. T. McK. Hughes pointed out that the classification given by Prof. Gaudry was purely chronological, whereas that suggested by Prof. Chamberlin was purely genetic. He then explained the abundance of striated boulders in one part of the glacial deposits and their absence in another. If the supply of material (that is, of rock bosses above the ice) ceases at any point, then all the boulders will gradually sink through the ice and become glaciated at the bottom. Prof. Hughes also thought that two distinct types of ridges formed of glacial material were confused under the names: kames, osars and eskar. He also explained the "pitted plains" as due to an unusual interruption between the hills or ridges of eskar character. He expressed his opinion that the glacial period was a continuous one, in England at least, except for slight changes due to unimportant oscillations.

Dr. Wahnschaffe advocated the chronological classification, and considered such a one possible for the Quaternary deposits of north Germany. These deposits begin with pre-glacial sands and gravels containing *Paludina diluriana*, which is still a living form and *Litoglyphus natoroides*. Above these follows a typical ground-moraine which is overlaid by stratified sand and gravel, containing the well-known diluvial fauna; and to these again succeeds the upper till, considered now as the ground-moraine of the second glacial epoch.

AFTERNOON SESSION.

Continuance of the same discussion.

Prof. H. Credner: The occurrence of the sand between two ground-moraines indicates a retreat and second advance of the ice sheet. Such interpolated sands are in Germany always local and no proof of a real interglacial epoch. The sand layers between the moraines are not continuous, but local, and cannot be given the significance attributed to them by Wahnschaffe.

Prof. Pavlow: In order to secure a satisfactory classification of Quaternary deposits, we must secure a satisfactory definition of Pleistocene. Prof. Pavlow said he would like to give his own views, but would postpone them until such accepted definition had been arrived at.

Baron de Geer agreed with Wahnschaffe that the chronological classification is at least locally possible. He also recognized two glacial epochs, due to two great oscillations. These cannot always be separated, as, for instance, in Russia. For this reason it is best to commence with a genetic classification, since this causes less confusion to the field geologist.

Dr. Wahnschaffe replied to Prof. Credner's assertion that there is no proof of an interglacial period in northern Germany. He thought that the existence of a diluvial fauna between the two tills is sufficient proof.

Prof. Credner replied that no complete skeleton had been found, but only single bones which might have been transported and deposited with the gravel.

Dr. Wahnschaffe again replied that the bones occurring in these gravels are proportionately large, when compared with the gravels themselves, and therefore cannot well have been transported from a distance.

Prof. Shaler: Organic deposits may possibly occur very near the ice sheet, which allows an interweaving of organic and glacial deposits.

Mr. G. K. Gilbert remarked on the observation of I. C. Russell in Alaska, that where the movement of the ice is very sluggish, it may become covered with soil, or even with a growing forest, in which such animals as bears still live.

Dr. Diener remarked that intercalated beds of sand were no positive proof of interglacial periods. In the Austrian Alps moraines no more than twenty years old are covered with pasture, and in the Caucasus the rhododendron grows to the very edge of the ice.

Dr. Holst mentioned two moraines separated by interpolated sand and thought that they might both have been formed by the same ice sheet. The melting of the ice leaves an unoxidized (blue) ground-moraine, with an overlying oxidized (yellow) upper moraine. This occurs in northern Sweden where there is no indication of a retreat of the ice.

Baron de Geer could not understand the occurrence of thirty or forty feet of stratified sand between two moraines of the same glacier. The colors are sometimes the reverse of what has been stated by Dr. Holst, and the boulders in the two moraines have been derived from different sources.

Mr. Christie described the section of peat and silt between two layers of till, occurring on the river Clyde, above Glasgow.

Mr. Cadell described some five distinct layers of till occurring in a

pre-giacial river channel in eastern Scotland; and also mentioned another river channel, filled with coarse gravel derived from rocks occurring farther north in Scotland which was covered with a later layer of boulder clay.

Mr. McGee mentioned the importance of land forms in interpreting geological processes. Any primary geological classification must be genetic. He discussed in detail the following scheme of classification of Pleistocene deposits:

Classification of Pleistocene Formations and Land Forms.

A. Aqueous:
   1. Below base level.
      a. Marine.
      b. Estuarine.
      c. Lacustral.
   2. At base level.
      a. Littoral.
      b. Marsh.
      c. Alluvial (certain terraces, etc.).
   3. Above base level.
      a. Torrential.
      b. Talus (including playas).

B. Glacial:
   1. Direct. (Chamberlin's class I.)
   2. Indirect. (Chamberlin's classes II to V, in part.)

C. Aqueo-Glacial: (Chamberlin's classes II to V, in part.)

D. Eolic: (Chamberlin's class (?) VI.)

E. Volcanic:
   1. Direct.
      a. Lava sheets.
      b. Cinder cones.
      c. Tuffs, lapilli sheets, etc.
   2. Indirect.
      a. Ash beds.
      b. Lapilli sheets.

Prof. Chamberlin, in closing the discussion, said that there was great difficulty in applying a chronological classification, and that such a classification might even act as a barrier to observation and to the recognition of the truth. Chronological classification is the ultimate goal of glacial studies, but it is something for which we are not as yet prepared. Red, oxidized sub-soils are not developed in northern latitudes. Organic deposits between glacial layers are abundant in the West, but do not belong to a single horizon. Many facts of erosion and physical geology indicate that the glacial epoch in America was widely differentiated and of long duration. How many distinct periods it embraced we do not as yet know.

Prof. Cope: An abundant tropical fauna is found in the "Equus beds," which, if they be of interglacial age, indicates at this time a very warm climate. This fauna is succeeded by a truly boreal fauna. In this is

contained material for a chronological sub-division of Pleistocene deposits.

SESSION OF AUG. 28, 1891, 11:40 A. M.

Prof. J. Le Conte, Vice-President, in the chair.

Announcements by the General Secretary, Mr. S. F. Emmons, relative to the minutes of yesterday and to various excursions.

Announcement by major Powell in regard to the essays on correlation to be published as bulletins of the U. S. Geological Survey.

The President then announced as the subject for discussion, the Correlation of Geological Formations.

Mr. Gilbert opened this discussion by presenting a general classification of methods of correlation.

Strata are locally classified by superposition in chronologic sequences. Geologic correlation is the chronology of beds not in visible sequence. For convenience in discussion, methods of correlation are classed in ten groups, of which six are physical and four biotic.

PHYSICAL METHODS OF CORRELATION.

1. Through visible continuity. The outcrop of a bed is traced from point to point and the different parts are thus correlated one with another.

2. Strata are correlated on account of lithologic similarity. This method, once widely prevalent, is used where the distances are small.

3. Correlation by the similarity of lithologic sequence has great and important use where the localities compared fall within the same geologic province, but it is not safely used in passing from province to province.

4. Physical breaks or unconformities, have a limited use, especially in conjunction with other methods. The practice of employing them in the case of localities wide apart is viewed with suspicion.

5. Deposits are also correlated with their simultaneous relations to some physical event; for example, a beach with the lake beds it encircles; a base level plane with a contiguous subaqueous deposit; and alluvial, littoral, and subaqueous deposits standing in proper topographic relation. In the Pleistocene, glacial deposits are widely correlated with reference to a climatic episode assumed to arise from some general cause.

6 Deposits are correlated through comparison of changes they have experienced from Geologic processes supposed to be continuous. Newer and older drift deposits in different regions are correlated according to the relative extent of weathering and erosion; induration and metamorphism afford presumptive evidence of age, but yield to evidence of other character. Metamorphism holds prominent place in the correlation of Pre-Cambrian rocks where most methods are inapplicable.

These physical methods are qualified by the geographic distribution of Geologic processes of change and of geologic climates.

BIOTIC METHODS OF CORRELATION.

7. A newly-discovered fauna or flora is compared with a standard series of faunas and floras by means of the species it holds in common with them severally.

8. It is also compared by means of representative forms, or through genera and families.

7*a* and 8*a*. These comparisons are strengthened if two or more faunas in sequence are found to be systematically related to the faunas of a standard series.

9. Two faunas or floras otherwise related are compared in age through their relation to the present life of their localities. This method was applied by Lyell to Tertiary rocks.

10. Faunas are correlated by means of their relation to climatic episodes, taken in connection with station. For example, boreal shells found in latitudes below their present range are referred to glacial time.

In general the limitations to accurate correlation by biotic methods arise from the facts of geographic distribution. Correlations at short range are better than those at long range.

Biotic correlation by means of fossils of different kinds may have different value. In general, the value of a species for the purposes of correlation is inversely as its range in time, and directly as its range in space. The value of a biotic group depends (1), on the range of its species in time and space; (2), on the extent to which its representatives are preserved.

Prof. K. von Zittel spoke in reference to the biotic methods and gave his opinion of the relative value of plants and animals for purposes of correlation. He regarded plants as relatively unimportant. Among animals those which are marine, lacustrine and land animals may be distinguished. Of these classes marine invertebrates are most valueable for purposes of correlation. The vertebrates change rapidly but are frequently altogether wanting. For instance, no vertebrates occur in the Alpine beds corresponding in age to those which contain the mammalian fauna of the Paris basin. In certain lacustrine deposits invertebrates may be absent, and in such cases the vertebrate fauna is the surest guide.

Baron de Geer emphasized the importance of a numerical comparison between different species. The actual counting of individuals in a given formation is of great value.

Prof. Marsh expressed his agreement in general with the conclusions communicated by Prof. von Zittel, but would give special weight to vertebrate fossils. In the Mesozoic and Tertiary beds of the Rocky Mountains he had found that the vertebrates offer the surest guide for correlation. This is in part because invertebrates are either wanting or are lacustrine. Prof. Marsh in 1877 named a sequence of horizons after the most characteristic vertebrate genus in each which is confined exclusively to it. He presented an outline of such classification brought down to date with a section to illustrate vertebrate life in America.

AFTERNOON SESSION.

Mr. C. D. Walcott spoke of the value of plants for purposes of geologic correlation.

Prof. T. McK. Hughes spoke of the present and growing tendency toward a natural classification. The evidence is complex and includes a

considerable variety of diverse relations. He pointed out exceptions to the normal conclusions deduced from superposition, lithological character, and similarity of sequence. We must have a system of criteria so varied that if one or more fails others can be employed. All classes of evidence are useful, both positive, negative, and circumstantial.

Major J. W. Powell spoke of the necessity of specialization on the part of geologists engaged in the work of correlation. The evidence derived from physical and biotic facts might apparently disagree. But that a satisfactory result may be reached, these two classes of evidence must be brought into harmony. He cited an example from his own experience of how an identification of synchronous formations might be made over a wide area through a union of physical and biotic methods.

Mr. W. J. McGee remarked that in the costal plain of the United States physical correlation alone is employed. The bases accord with those outlined by Mr. Gilbert with certain minor modifications and an important addition, as follows:

For local discrimination and correlation	Visible Continuity; Lithologic similarity; Similarity of sequence.
For correlation throughout the province	Physical breaks viewed as indices of geography and topography.
For correlation with contiguous provinces.	Relation to physical events, including continental movements, transportation of materials, land sculpture, etc.
For general correlation, - - -	Homogeny or identity of origin.

By correlation upon these bases the physical history of a considerable fraction of the continent may be so definitely ascertained as to permit fairly accurate mapping of the geography, and even the topography of each episode in continent growth. After these episodes are clearly defined, and the fossils found in the formations are studied, it will be possible definitely to ascertain the geographic distribution of organisms during each episode, then paleontology may be placed on a new and higher plane.

Prof. W. M. Davis showed that it was possible to decipher geological history not only through the records of deposition, but also by processes of degradation. As an example of this method he explained a topographical section from the city of New York westward. In this we have evidence of the existence of an ancient "*peneplain*," or base-level lowland of Cretaceous age. This surface was subsequently elevated (more toward the west than toward the east) at the end of Cretaceous, or at the beginning of Tertiary time. It has since been dissected by the excavation of more recent valleys. The Hudson valley lowland was cited as an example of this recent dissection.

Prof. E. W. Claypole considered that the different methods of geologic correlation differed very greatly in their value. It is improbable that the plant or mammalian record will ever equal in its perfection that of the marine invertebrate fauna. The marine fauna is to the geologist what a primary triangulation is to the geodosist. It marks out the main divisions, which are subsequently further subdivided through the aid of other fossils, such as plants and vertebrates.

Prof. C. R. Van Hise spoke of the methods of correlation employed for pre-Cambrian rocks, which occur in widely separated areas and are devoid of fossils. Physical data only are available for correlating these formations. Experience has shown that among all physical methods, unconformity is by far the most important. Other physical criteria, such as the degree of induration, metamorphism, and relation to eruptives, are valuable for the subdivision of single areas, but cannot be safely used in identifying synchronous formations in widely-separated areas. The idea that lithological character is any direct proof of geological age has retarded the scientific subdivision of pre-Cambrian rocks. The researches of Pumpelly and others in the eastern United States have demonstrated that Silurian, Devonion, and even Carboniferous deposits might become, under certain physical conditions, as highly crystalline as much more ancient rocks of the West. For this reason it has been found necessary to abandon such term as *Huronian* and *Keweenawan*. Evidences of life are not lacking in pre-Cambrian rocks, and it is to be hoped that the paleontologist will succeed in differentiating several separate formations below the Cambrian, as the Cambrian itself was differentiated from the base of the Silurian.

SESSION OF AUG. 29, 1891, 10 A. M.

Prof. Albert Gaudry, Vice President, in the chair.

Mr. S. F. Emmons, General Secretary, made announcements.

M. Alexis Delaire presented two communications in behalf of prince Roland Bonaparte relating to the phenomena of the Aletsch glacier and upon an excursion to Corsica.

Prof. Chas. Barrois presented a communication on behalf of Prof. Michel Lévy upon the geologic history of the Auvergne volcanoes, containing a classification of eruptive rocks as represented by symbols.

Prof. E. W. Hilgard laid stress upon the importance of the abundance or scarcity of species in the correlation of strata. He thinks some quantitative estimation of the species should be made. He is of the opinion, also, that as compared with marine fauna, plants have but little value, for purposes of correlation owing to their local distribution, their accidental proximity to water, transportation, and preservation. Plants can be so used only after large areas are worked over.

Prof. Zittel was called to the chair, and Prof. Lester F. Ward then continued the discussion. He developed two of the more general principles of correlation by means of fossil plants, as follows:

I. That the great types of vegetation are characteristic of the great epochs in geology.

This principle is applicable in comparing deposits of widely different age when the stratigraphy is indecisive. For example, even a small fragment of a Carboniferous plant proves conclusively that the rocks in which it occurs are paleozoic, or a single dicotyledonous leaf proves that they must be as late as the Cretaceous.

II. That for deposits not thus widely different in age, as for example, within the same geologic system or series, ample material is necessary to fix their position by means of fossil plants.

Neglecting this principle has led to the greater part of the mistakes of paleobotanists, and has done most to bring paleobotany into disrepute. Geologists have expected too much of them, and they, in turn, have done violence to the truth in attempting to satisfy extravagant demands. On the other hand, where the material is ample, fossil plants have often corrected the mistakes of stratigraphical geologists, and solved problems concerning geologic age, which seemed impossible of settlement by any other class of evidence.

Mr. Chas. D. Walcott spoke upon the correlation of the Cambrian rocks of North America. The principles used now are the same as those used by the New York survey prior to 1847 except that those principles have been somewhat modified by the theory of evolution. Both physical and biotic data are available in the correlation of the Cambrian rocks on the Atlantic coast, of the Rocky Mountain areas, and of the interior continental plain. Throughout the Appalachian provinces the physical data suffice to correlate the Lower Cambrian from Vermont to Alabama, but such data are not sufficient to correlate it with that North of the St. Lawrence valley. The correlation of the deposits of the Appalachian and the Rocky Mountains troughs were by biotic data alone, and of the great extent of the Upper Cambrian over the continent the biotic data correlated the Rocky Mountain Upper Cambrian with that of the interior and the Appalachian area.

The correlations made indicate that in Lower and Middle Cambrian time a great continental area existed over the interior, and all the Cambrian sediments were accumulated in troughs west of the Appalachian and Rocky Mountains. In Upper Cambrian time the interior of the continent sank beneath the ocean, and the sandstones of the upper Cambrian were deposited, and the result of these correlations add a chapter to the history of the evolution of the North American continent.

Prof. James Hall spoke of the difficulties encountered in the earliest attempts at correlation of the rocks even in the state of New York. He urged the importance of taking into consideration both physical and faunal characters of the rocks. In some cases, however, the physical characters of the rocks change greatly in passing from one region to another--sandstones grading into limestones, and limestones into shales —and these beds may also vary greatly in thickness. Fossils are of unequal value in such correlations: Lamellibranchs are near shore forms and fail in deep water; they are not, therefore, so valuable as Brachiopods, which have a wider distribution, for purposes of correlation.

Prof. Henry S. Williams laid stress upon the relations of species to the conditions of deposition. The abundance of a species varies with environment, and a study of correlation should embrace a study of these conditions. Sandstones deposited near shore may have a fauna different from that of a limestone deposited off shore at the same time, and a change of fauna may be induced by a change of the conditions of deposition. The age of beds should be determined by comparing species of the same genera rather than by comparing those of different genera. There are centres of abundance which exhibit great variability

in their characters; outside of these centres the species exhibit varieties which may be called extra-limital, and which are not typical though they have often been published as types.

Dr. F. Frech said that in comparing the middle paleozoic fauna of Europe with that of North America, there were two principal points of especial interest:

A. The identity of some comparatively small horizons.

B. The far greater differences that exist in these same beds.

The similar faunas are—

1. That of the Niagara and of the Wenlock shales.

2. In the Upper Devonian the Rhynchonella of the Tully limestones and the Goniatites of the so-called Naples beds.

3. The Goniatites at the base of the Carboniferous in Iowa, in Spain, and in middle Germany.

The Hamilton fossils are of especial interest because we have on the Rhine, in the so-called Lennenschiefer, a fauna of the same facies. But while these rocks were deposited under similar physical conditions, the number of identical species in the two countries is very small, and there are many genera in each country not found in the other. All the Lower Devonian is wanting in European Russia and part of it is wanting in middle Germany, but the great physical change which followed is sufficient explanation for the differences which characterize the junction of the Devonian and Silurian.

Prof. Barrois thinks it impossible to compare in detail American and European rocks. Some individual zones of the American series can be correlated with European horizons, but it is quite impossible to establish in detail the identity of other and adjacent zones.

Prof. C. R. Van Hise spoke of the distribution, character, and succession of the pre-Cambrian sedimentary rocks of North America. All rocks are regarded as pre-Cambrian which are earlier than the Olenellus fauna. These rocks contain the evidence of abundant life as shown by thick beds of carbonaceous shales, by various distinct fossils, and in many other ways. When a less highly developed fauna is found, as different from the Cambrian fauna as the Cambrian is from the Silurian, it is best to give this fauna a new name.

There are in many areas in North America great thicknesses of little altered pre-Cambrian sedimentary rocks. In many regions these rocks have been separated into series by wide-spread unconformities, and these series have been farther divided into formations. Some of the more important pre-Cambrian regions are Lake Superior and Lake Huron, Central Arizona, New Brunswick, Newfoundland, Southwestern Montana. As an illustrative example of the successions may be cited the first. In this area the descending order is Lake Superior sandstone (Potsdam), unconformity, Keweenawan, unconformity, upper Huronian, unconformity, Lower Huronian, unconformity, basement crystalline complex. Each of these series is divided into several formations.

In individual regions it is possible to correllate series and formations upon a physical basis. In different regions the series have variable

lithological characters and unlike successions. Because of the absence of a well-known pre-Cambrian fauna it is impracticable at present to make correlations in far-distant regions. Hence the term Algonkian has been proposed by the United States Geological Survey to cover the whole of the pre-Cambrian clastics. No working geologist in America now holds the indivisibility of the pre-Cambrian in all regions.

If the foregoing conclusions are correct, the invariable succession advocated by Hunt, evolved almost wholly within the laboratory, is valueless. It is shown to be untrue at one or more fundamental points by the observed order of the rocks in every region in which there are tolerably full successions.

Prof. R. Pumpelly confirmed the observations of Prof. Van Hise in so far as he had been over the ground mentioned. He referred especially to observations made in the Green mountains, where in one locality metamorphism has completely masked the original character of the rocks, and thus rendered impossible correlation by lithologic characters, As an example he cited a formation which is a quartzite, at one point. a white gneiss containing new feldspars at another, a conglomerate without any schistose structure at another, and a mica schist at a fourth locality.

Prof. Chas. Barrois, referring to the remarks of Prof. Van Hise, said that there was no general basis, either biologic or lithologic, for the correlation of the pre-Cambrian rocks of Europe with those of North America; even the terms applied to these rocks were liable to be misunderstood. Certainly the divisions used in France cannot be correlated with those now used in the United States. General correlation cannot, as yet, be based upon non-conformities; autopsy is the only basis upon which a comparison can be instituted. He pointed out certain parallelisms between the histories of the crystalline schists of America as illustrated by Mr. Pumpelly and the gneissic rocks of Brest, where the Cambrian slates are altered to gneisses of Archæan aspect, while the alternating fossiliferous quartzites are changed to crystalline quartz. Geologists must see the beds together in order to reach a common understanding of the crystalline rocks.

Dr. Chas. A. White was called upon, but in view of the divergence of the discussion from the topic as originally taken up, excused himself from speaking upon the subject.

Prof. E. D. Cope discussed the question from a general point of view with especial reference to the value of vertebrates for purposes of correlation, particularly for inter-continental correlation. He pointed out that there is a marked difference in the present vertebrate faunas of continents, and that the variation of such forms must be sought in vertical rather than in horizontal ranges. Such study shows that we have had invasions of a given region by a fauna from without; for example, a South American fauna invaded North America at one time and then retreated, while a North American fauna once invaded South America and traces of it still remain in that country. He is inclined to believe that certain vertebrate forms did not spread over the earth from a single

place of origin, but that they originated at different places upon the earth. We have parallelism in separate places, but the parallelism is defective in the Laramie.

Mr. G. K. Gilbert was of the opinion that many methods of correlation must be used. He doubted the trustworthiness of the correlation of non-fossiliferous rocks by comparative change, even locally. He thought the abundance and scarcity of fossil forms comparable with lithologic differences, and considered the simple occurrence of a species as valuable for purposes of correlation as its abundance.

Prof. Van Hise explained that the distinction between the Algonkian and the Archæan has not been widely made in Europe, because there, as in the Appalachian region, later and powerful dynamic movements have repeatedly occurred.

Prof. E. D. Cope added that life in its progress on the earth differed from minerals and rocks in that it has its own laws, which give it an independent element.

Announcements were made by Secretary Emmons, and the meeting adjourned at 1 o'clock until 11 o'clock A. M. Monday, August 31st.

SESSION OF AUG. 31, 1891, 11:25 A. M.

Prof. James Hall, Vice-President, in the chair.

Announcements were made by Mr. S. F. Emmons, General Secretary.

Subject for discussion: Map-coloring and Cartography.

Major J. W. Powell exhibited charts illustrating the color system used by the U. S. Geological Survey, explained the methods of using the colors, and gave the reasons for them. The colors assigned to rocks of different ages are as follows:

Period.	*Period color.*	*Mark.*
1. Neocene	Orange	N.
2. Eocene	Yellow	E.
3. Cretaceous	Yellow-green	K.
4. Jura-Trias	Blue-green	
5. Carboniferous	Blue	C.
6. Devonian	Violet	D.
7. Silurian	Purple	S.
8. Cambrian	Pink	
6. Algonkian	Red	A.

The colors are used to designate geologic periods, patterns of these colors designate formations; minor divisions are usually relegated to the text. The number of patterns for designating formations can be indefinitely enlarged, but follow a definite system.

Mr. Joseph Wilcox showed that in the scheme described by major Powell the colors were not evenly distributed through the chromatic scale.

Prof. C. R. Van Hise pointed out that Archæan rocks are shown by a brown underprint, and that metamorphic rocks of known age are given the color of the corresponding unaltered rocks.

Major Powell explained that it was not attempted to select colors

equally distributed through the chromatic scale, but to use those that may be most readily recognized.

Mr. H. M. Cadell asked why black and gray were not used.

Major Powell replied that blue was used in place of the dark shades for the Carboniferous; that dark colors are misleading in regard to the occurrence of coal, which occurs in the Cretaceous and Tertiary as well as in the Carboniferous.

Mr. Christie found the black color very inconvenient because it often made the details of the map covered by such colors illegible.

Mr. H. M. Cadell said that the maps of the Geological Survey of Great Britain were colored by hand, and that the system used by the U. S. Geological Survey could not for this reason be economically employed.

Major Powell explained that the U. S. Survey system is very economical when the color patterns are transferred to stones.

Prof. T. McK. Hughes thought it very difficult to devise a scheme that will meet the demands of everyone. Some reference must be had to the permanence of the colors, the readiness with which they can be applied, and the distinctness with which they show what is desired. He thinks the fittest scheme must survive.

Mr. S. F. Emmons made announcements.

On motion of major Powell, the program for the afternoon was changed so that the geology of the country to be traversed by the long excursion might be briefly described by those the most familiar with it.

Adjourned till 2:30 P. M.

On re-assembling at 2:30 P. M., Prof. Le Conte in the chair, brief lectures were given by Prof. Chamberlin, Mr. Gilbert, major Powell, and Mr. Emmons upon the geology of the country to be traversed by the long excursion.

Adjourned at 4:40 P. M.

As may be seen from the foregoing, the Congress was occupied with the problems proposed for discussion by the Committee of Organization, as was announced in the GEOLOGIST (Vol. VIII, p. 62), but there was an apparent lack of orderly preparation and of consistent succession in the proceedings from day to day. For instance, the topic which was expected, according to the program announced by the Committee of Organization, to come *last*, was called up the *first thing the first day*, and parties who might have wished to participate in the discussion were thereby prevented, or were obliged to offer their facts undigested and perhaps unarranged, or without the graphic illustrations which they otherwise would have employed. It was quite evident, also, that some of the gentlemen who led in the discussion of the daily topics were compelled to do so on too short notice. It might be well for future Committees of Organization to assume more

thorough direction of the doings of the Congress, as least so far as to see that parties are at hand with well prepared papers to bring the topics of discussion fully before the Congress. It is manifest that each new "Bureau" elected after the session opens, is in no degeee prepared to provide for this necessary guidance of the deliberations of the Congress. It is a precaution which ought to be taken several months, or perhaps several years, before the Congress convenes. The practice of national "nomenclature reports," which in this case might have been *correlation reports*, from the countries participating in the Congress, but which was apparently not attempted and not encouraged by the American organizing committee, would certainly subserve this purpose perfectly. This would be more likely to be satisfactory, being more "democratic," than that plan which was entered upon by the English organizing committee *in re* the crystalline schists. That committee solicited contributions from individuals on that specific topic. While this resulted in the production of a number of learned and very valuable contributions which grace the volume lately issued by the English committee, it cannot be considered as the best way to promote harmony and to extend and perpetuate an interest in the Congress. If the Congress be in fact an "international" one, the various nationalities should have systematized participation in its doings, and the organizing committee should be empowered and directed to take steps to facilitate such general participation. The late Congress passed off with the simple presentation, largely or entirely, of some American views on American geology, followed by such desultory comment or discussion as happened to spring up. If such a practice be perpetuated in future sessions, the Congress will finally degenerate to an elementary school of geology, wherein the visiting geologists will learn the outlines and general principles of the geology of the countries where the separate sessions may be held, and it will be a question of a short time, a very short time, whether the usefulness and the purposes of the Congress, as set forth by the founders, be not so far lost sight of or so remotely subserved that the sessions had better be discontinued.

The next session will be at Berne, Switzerland, and we wish to appeal to the intelligent geologists of that little republic, to early take measures to make the next session a truly "international" and representative one.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Comanche series of the Texas-Arkansas region. By ROBERT T. HILL. Bulletin, Geological Society of America, vol. ii, pp. 503-528; May 5, 1891. The main area of the Comanche series is stated to extend from western Arkansas through southern Indian Territory to the meridian of 97°30, thence southward and southwestward across Texas to New Mexico, a distance of more than 1,000 miles, and then southward indefinitely into Mexico. The series, as studied by Mr. Hill in central Texas and northward, is made up of eleven terranes, classed under three divisions in ascending order, as follows: A. The Trinity division, comprising 1. Trinity or basal sands, which Dr. C. A. White provisionally regards as the base of the North American lower Cretaceous; and 2. The Glen Rose or alternating beds, consisting of abundantly fossiliferous magnesian limestones, fine sand, chalk, and almost pure crystalline limestone. B. The Fredericksburg or Comanche Peak division, comprising 3. The Paluxy sands, about 100 feet thick, containing no fossils excepting silicified wood; 4. The *Gryphæa* rock and Walnut clays, the former being a stratum 10 to 50 feet thick, composed entirely of the shells of a small *Gryphæa*, and the latter being associated clay marls which enclose myriads of *Exogyra texana* Roemer; 5. The Comanche Peak chalk, about 100 feet thick, rich in many species of fossils; 6. The *Caprina* limestone of Shumard, an indurated chalk, 30 to 40 feet thick, preserved as the capstone of many buttes, mesas, and plateaus; and 7. The Goodland limestone, apparently an equivalent of the last two. C. The Washita or Indian Territory division, comprising 8. The Kiamitia clays or *Schloenbachia* beds, so named from their characteristic Ammonites; 9. The Duck Creek chalk, about 100 feet in thickness, composed of crumbling chalky limestone and marls, with a unique fauna; 10. The Fort Worth limestone, which with the last was described by Marcou at Fort Washita as typical Neocomian; and 11. The Denison beds, made up of sandy clays and occasional limestones, *Exogyra arietina* being the characteristic fossil of the clays. At Denison and throughout northern Texas, these beds are unconformably overlain by the Dakota sandstone, the base of the upper Cretaceous series which is so widely developed on the plains farther north.

Carboniferous fossils from Newfoundland. By Sir J. WILLIAM DAWSON. Bulletin, G. S. A., vol. ii, pp. 529-540, with two plates; May 27, 1891. The plants described or catalogued with annotation in this paper are from St. George's bay, in western Newfoundland, the most noteworthy species being *Lepidodendron murrayanum*, nearly like *L. cliftonense* of Nova Scotia. The strata are similar to those of the coal formation of Cape Breton, and have a total thickness of probably 11 000 feet. According to Mr. James P. Howley, now director of the Geological Survey of Newfoundland, they contain six beds of coal, ranging from fourteen

inches to eight feet in thickness, three of them having over four feet of good coal, apparently a free-burning bituminous variety, resembling that of the Cape Breton mines.

A proposed system of chronologic cartography on a physiographic basis. By President T. C. CHAMBERLIN. With *The geological dates of origin of certain topographic forms on the Atlantic slope of the United States.* By WILLIAM MORRIS DAVIS. Bulletin, G. S. A., vol. ii, pp. 541-544, and 545-586, with six figures in the text; July 2, 1891. Increasing attention has been given during recent years to topographic forms as time indices and means of geologic correlation. President Chamberlin therefore proposes a cartographic system, in which plains shall be represented by lines, and slopes by dotted surfaces, both to be put on in colors varying according to the geologic date of these topographic forms. The direction of the agency by which they were produced may also be shown. Thus, a fluvial plain will be indicated by arrows (without feathers) pointing in the direction of the current, while a lacustral plain will be mapped by parallel lines headed with arrows-points on the margin shore erosion by waves having been the most characteristic agency in its production. In the case of subaerial plains or peneplains, parallel lines will be used without arrow-heads. To distinguish between a plain and a peneplain, which may be quite rolling and yet clearly determinable, continuous lines may be used for the former and broken lines for the latter.

Professor Davis recognizes a Cretaceous peneplain in southern New England, New York, New Jersey, and southward, into which the rivers of the Atlantic slope have cut broad and deep valleys during the Tertiary era. The Hudson river, for example, is shown to have excavated the whole gap between the Catskill and Berkshire plateaus since the early Tertiary uplifting of this peneplain. The level crests of the Appalachain ranges are remnants of the Cretaceous base-level, into which streams have channeled the great intervening valleys during Tertiary and Quaternary time; but the White mountains of New Hampshire and the Black mountains of North Carolina have existed, constantly undergoing denudation, from much earlier dates.

Variations in the Cretaceous and Tertiary strata of Alabama. By DANIEL W. LANGDON, Jr. Bulletin, G. S. A, vol. ii, pp, 587-606, with one plate; July 8, 1891. This paper presents detailed descriptions and sections observed during the boat journeys down the Tombigbee, Tuscaloosa, and Alabama rivers, with which the sections exposed farther east by the Conecuh, Pea, and Chattahoochee rivers are compared. Special attention is directed to variations in the strata on account of different conditions of sedimentation, to faunal changes, and to unconformities due to the total absence eastward of formations that are well defined in the western part of the state. On the Tombigbee the Cretaceous beds measure about 2,500 feet in thickness, and the Eocene about 1,655 feet; while on the Chattahoochee these are reduced respectively to about 1,440 and 1,140 feet

Bulletin of the Geological Society of America, Proceedings of the third annual meeting, held at Washington December 29, 30 and 31, 1890. J. J. STEVENSON, Secretary. pp. 607-662; August 7, 1891. Besides a record of the order of presentation of the various papers which have been separately printed by the Society and already reviewed in this and preceding numbers of the GEOLOGIST, six short papers are here printed in abstract or fully, as follows: On the occurrence of *Megalonyx jeffersoni* in central Ohio, by Edward Orton; On the family Orthidæ of the Brachiopoda, by James Hall; On a jointed earth auger for geological exploration in soft deposits, by N. H. Darton; On the occurrenceof diamonds in Wisconsin, and on the occurrence of fire opal in a basalt in Washington state, by George Frederick Kunz; and A fallen forest and peat layer underlying aqueous deposits in Delaware, by Hilborne T. Cresson. The first annual report of the committee on photographs, gives the titles, with descriptive notes, of 293 photographs received by the Society in 1890, of which 21 were donated by Prof. J. F. Kemp of Ithaca, N. Y.; 269 by the U. S. Geol. Survey, through the director, major J. W. Powell; and 3 by Prof. W. B. Dwight of Poughkeepsie, N. Y.

Arkansas Geological Survey, J. C. BRANNER, state geologist; Annual report for 1890, Vol. 1, *Manganese, its uses, ores and deposits,* R. A. F. PENROSE. Octavo, 642 pp., geological map. Little Rock, 1891.

This volume is a valuable one for the manganese industry in Arkansas, and secondarily for all who make use of manganese. It gives an account of the early and modern uses of manganese, and brings out vividly the remarkable recent increase of its mining and manufacture (in spiegeleisen and ferro-manganese) in the United States. In 1875 the net tons produced were 7,832, in 1885 34,671, and in 1890 149,959 tons. The methods of use of manganese in the arts, including its alloy with iron in the Bessemer and Hadfield processes of steel-making are fully described. Small amounts of manganese ore were mined in the United States (Tennessee) as early as 1837, but at the present time Virginia, Georgia and Arkansas produce over nine-tenths of the total output of North America. "The United States is the next largest producer of manganese ore in the world, being second only to the Caucasus region of Russia." "England is the largest consumer of manganese in the world, using not only its own production, but also 74,906 tons from outside sources. The United States is not only the second producer but the second largest consumer, using its own production as well as that of Cuba, and most of that of Canada."

All the various ores and minerals of manganese, together with their places and manner of occurrence, are described, embracing also chemical analyses.

In Arkansas there are two manganese regions, one in the northeastern part of the state, known as the Batesville region, of which a detailed geological map is given, and the other in the southwestern part extending from Pulaski county through Polk county to the Indian Territory

border. In the former occur nearly all the large and workable deposits.

The ores of the Batesville region occur in a residual clay, derived from the decay of a limestone which, according to Prof. H. S. Williams, occupies a position intermediate between the Trenton and the Niagara limestones. The ores of the southwestern part of the state are in novaculite probably of Lower Silurian age, perhaps Trenton. The ores in both regions are in the forms of the various oxides of the metal. These ores were mentioned by Owen and Cox, and Featherstonhough mentioned manganese in the southeastern part of the state, but it is only within a few years that there have been systematic working and descriptions of the deposits.

Between the ore-bearing St. Clair limestone, which is of about the age of the Trenton, and the Boone chert which is a part of the lower Carboniferous, is a curious clayey deposit which is partly the result of surface decay of the lower limestone, and partly apparently of the nature of eruptive ash. This has been but partially investigated, but it seems to be widespread, and points to a long land exposure in this region between the close of the Lower Silurian and the age of the Carboniferous Boone chert. This had already been suggested by Dr. Branner from examinations in the field. Like the Cincinnati anticlinal, therefore, this part of the country experienced an elevation, but not like that, this remained dry land through the upper Silurian and the Devonian, and was subsequently again sunk beneath the ocean.

In the careful description of the manner of occurence of the ore in the Batesville region is ample proof of the thoroughness and ability with which the investigation has been carried on. It is a comparatively new field, and it has been most satisfactorily worked. The ore occurs in a clay which is the residuum of the St. Clair limestone. The ore was first in the limestone. The decay of the rock, and the removal of the soluble part has concentrated the insoluble, this embracing the ores—which, however, have to some extent been converted from carbonates. This process of decay began after the last elevation of the region above the ocean and is still going on. This residual clay has nothing to do with the layer of residuum which naturally intervenes between the St. Clair limestone and the Boone chert already mentioned, as to its age and stratigraphic relations, however closely they may be related genetically.

The report embraces a review of the manganese mines of the United States, with a view to comparison with those of Arkansas, for the purpose, evidently, of arriving at some conclusion as to the origin of the ore in the rock from which it is now plainly derived by natural concentration *in situ* through slow decay. In the course of this review, Dr. Penrose describes, with more fullness and correctness than has ever been done before, the manner of the occurrence of the iron and manganese ores of Vermont, and their stratigraphic relations. In this he adopts the late conclusions of United States geological survey (by J. E. Wolff), that the associated rocks are of the age of the Lower Cambrian, or Taconic of the region, as has been claimed from the time of Emmons

till now, except by those who reject the Taconic system. He finally reaches the conclusion that the ores (in particular the ore of manganese, although the conclusion involves that of iron because of their intimate association) were the result primarily of chemical precipitation in the ocean at the time of the formation of the rocks themselves, and that the oceanic waters obtained the manganese principally from the disintegration of the older crystalline rocks of the region.

The report is faultless in method and execution, and the value of its scientific conclusions, and of its accurate and conscientious descriptions of Arkansas localities cannot fail to be highly appreciated by the citizens of that state. It is, moreover, a real contribution to the geology of the country, and adds one more to the series of valuable results of the Arkansas survey.

RECENT PUBLICATIONS.

I. *State and Government Reports.*

Geol. Sur. of Missouri, Bulletin No. 5, contains: The age and origin of the crystalline rocks of Missouri, Erasmus Haworth; Notes on the clays and building stones of certain western-central counties tributary to Kansas City, G. E. Ladd.

Advance sheets from the 17th report of the Geological Survey of the State of Indiana; Pateontology, S. A. Miller, 113 pp., 22 plates.

Geol. Survey of Georgia, First report of Progress, 1890-91. J. W. Spencer.

Bulletin No. 80, U. S. Survey. Correlation papers, Devonian and Carboniferous, Henry S. Williams.

Second annual report of the Geological Survey of Texas, E. T. Dumble, contains, besides the report of the state geologist, the following papers: Reports on the iron ore district of East Texas; Carboniferous cepholopods, A. Hyatt; Report on the geology of northwestern Texas, W. F. Cummins; Report on the geology and mineral resources of the central mineral region of Texas, Theo. B. Comstock; Report on the geology and mineral resources of Trans-Pecos Texas, W. H. Von Streeruwitz.

II. *Proceedings of Scientific Societies.*

Trans. N. Y. Acad. Sciences. Feb-March, contains: The man of Spy, or newly discovered paleolithic skeletons from the vicinity of Liège. Belgium. J. S. Newberry; The tin deposits of North Carolina. John H. Furman. April to June: Amber, its history, occurrence and use, J. S. Newberry; Remarks on recent discoveries in local Cretaceous and Quaternary geology, N. L. Britton; The Pipe-creek meteorite, A. R. Ledoux.

Jour. Cin. Soc. Nat. Hist., July, 1891, contains: On the age of the Pt. Pleasant, Ohio, beds, Jos. F. James.

Appalachia, July, 1891, contains: A classification of mountain ranges according to their structure, origin and age, Warren Upham.

Recent discoveries bearing on the antiquity of man. G. F. Wright. (Bibliothica Sacra, Apr., 1891.)

Description of a skull of *Megalonyx leidyi*, n. sp., Josua Lindahl. (Am Phil. Soc., Read Jan. 2, 1891.)

III. *Papers in Scientific Journals.*

Kansas City Scientist, July, contains: Some new species of echinodermata, R. R. Rowley and Sid. J. Hare. August: Some new species of crinoids and blastoids, R. R. Rowley and Sid. J. Hare.

Ottawa Naturalist, July, contains: Extinct Canadian vertebrates from the Miocene rocks of the Northwestern territories of Canada, H. M. Ami.

American Naturalist, July, contains: A review of the "Discovery of the Cretaceous Mammalia," H. F. Osborn; Notes on Mesozoic mammalia, O. C. Marsh; The coming man, S. V. Clevenger; On the relations of Carettochelys, Ramsay G. Baur; on some new fishes from S. Dakota, E. D. Cope.

IV. *Excerpts and individual publications.*

On paramelaconite and the associated minerals, Geo. A. Koenig. (Proc Acad. Nat. Sci. Phil. April, 1891.)

Geological Guide-book of the western excursion of the Fifth International Congress of Geologists, S. F. Emmons, 8vo. pp. 156, Washington.

On an important boring through 2,000 feet of Trias. in eastern Pennsylvania, J. P. Lesley. (Am. Phil. Soc. May 23, 1891.)

Manual of the paleontology of the Cincinnati group, Jos. F. James. (Jour. Cin. Soc. Nat. Hist. Apr., 1891.)

The development of a paleozoic poriferous coral, and Symmetrical cell development in the Favositidæ, Charles E. Beecher. (Trans. Conn. Acad., Vol. VIII, 1891.)

The universalty of man's appearance and primative man, Edward L. Anderson. 8vo. 28 pp. Edinburgh, 1891. Cincinnati, Robt. Clarke & Co.

On the Grapeville gas-wells, J. P. Lesley. (Am. Phil. Soc. Apr. 27, 1891.)

Notes on Central-American Archæology and Ethnology, J. Crawford. (Bos. Soc. Nat. Hist. Feb., 1891.)

V. *Foreign Publications.*

Proc. and Trans, Nova Scotia Institute of Science, Vol. VII, Part 4, contains: Glacial Geology of Cape Breton, Honeyman; Geological Gleanings in Nova Scotia and Cape Breton, Honeyman; The Geological Writings of Rev. D. Honeyman, Gilpin; The Devonian of Cape Breton, Gilpin; Surface Geology of the Pictou Coal Field, Poole; A Contribution to the Theory of Earthquakes, Maury.

Bul- Soc. Sci. Nat. d. l'ouest de la France, Tome I, No. 1, contains: Etude du metamorphisme aux environs de Nozay, Loire-inférieure, Davy; Archéen et le Cambrien dans le Nord du Massif Breton et leurs

équivalents dans le Pays de Galles, Bigot; Sur la présence du Carbonifère en Bretagne, Lebesconte; Sur un gisement carbonifère de l'étage de Visé reconnu à Quenon, en Saint Aubin-de-Luigné, Bezier.

Tome I, No. 2, contains: Etude petrographique des eclogites de la Loire-inférieure, La Croix;

Archiv d. Ver. d. Freunde d. Naturgeschichte in Mecklenburg, 1890, contains: XII. Beitrag zur Geologie Mecklenburgs, Geinitz; Ueber das angebliche Vorkommen Geschieben des Hörandsteins in den norddeutschen Diluvialablangerungen, Nathorst; Das meteor von Kröpelin, Geinitz;

Fold. Köz. (Budapest). Vol. XXI. Nos. 4 and 5 contains: Awaruit, ein nickeleisen-mineral, Szabo; Beiträge zur Foraminiferen-fauna der Alttertiären Schichten von Kis-Gyor, Kocsis.

Boletim da Commissao geographica e geologica do estado de S. Paulo, No. 7, contains: Notas sobre zeolitas do augito-porphyrito de S. Paulo e Santa-Catharina, Hussak.

Cursu elementaru de Geologia, de Gregoriu Stefanescu, pp. 256, 8vo, Bucharest, 1890.

A manual of the Geology of India, Part IV, Mineralogy (mainly non-economic), F. R. Mallet. Calcutta, 1887, pp. 179. Roy Oct.

Die landeskundliche Literatur über de Grossherzogtümer, Bachmann, Güstrow, 1889, pp. 511.

Report of the inspector of mines for North Walés and Isle of Wight, for 1890, C. Le Neve Foster. London, 1891.

List of mines worked in 1890 in the British Islands. By the inspectors of mines.

Ueber den Sagvandit. H. Rosenbusch, (Neues Jahr, 1884.)

Die Urvierfüssler (Eotetrapoda) des Sächsischen Rothliegenden, Hermann Credner. (Natur. Wochens. Berlin), 1891.

Zur Auffassung des Grundgebirges, H. Rosenbusch. (Neues Jahrb. Bd II. 1889. Heidelberg.)

Ueber Monchiquit, ein camptonitisches Gangestein aus der Gefolgschaft der Eläolithsyenite. Hunter and Rosenbusch (Tschermak's Mitth. Min. und Pet. 1891.)

Zur Auffassung der chemisches Natur des Grundgebirges, H. Rosenbusch. 1891. (Tschermak's Mittheil. Wien.)

An outline of Mr. Mellard Reade's Theory of the Origin of Mountain Ranges by sedimentary loading and cumulative recurrent expansion; in answer to recent criticisms. T. Mellard Reade. (Phil. Mag. June, 1891).

PERSONAL AND SCIENTIFIC NEWS.

THE GEOLOGICAL MAP OF EUROPE. "I received an invitation from Berlin signed by Beyrich and Hauchecorne, to meet them at Saltzburg (Austria) as a member of the committee of the *geologi-*

cal map of Europe, of which I have heard nothing for three years. Besides the two Prussians Mojsisovics came from Austria, and Renevier from Switzerland, and nobody else of the committee. No one came from England, nor from France, nor Russia. Only Capellini joined me as an Italian friend. Nothing new worth noting was said or done, except that the announcement was made that *very likely* the first sheet of the map, scale 1. 500,000, will be issued before the year is over." GIORDANO, *director of the geological survey of Italy*, Aug. 18.

WASHINGTON UNIVERSITY, St. Louis, has just chosen a science-bred president, W. S. Chaplin, late professor of Engineering at Harvard University.

PRESERVATION OF THE GLACIAL GROOVES OF KELLY'S ISLAND. Through the active interest and intercession of Prof. G. F. Wright, Mr. M. C. Younglove, president of the Kelly's Island Lime and Transport Company, has been empowered to deed to the Western Reserve Historical Society of Cleveland, a portion of the land on Kelly's island, "fifty feet wide and one hundred feet long," on which is preserved a part of the remarkable ice-grooving, which was visited by an excursion of the American Association for the Advancement of Science at the Cleveland meeting in 1888. These grooves are certainly the most remarkable ever discovered in this country, and they are to be preserved as an object lesson to future generations. Quarrying has already proceeded nearly all around this specimen, and soon the monument preserved will be a monument indeed; the groove being left to cap a pedestal about thirty feet high, and conspicuous from every side. About one-half the surface will be cleared of debris, so as to show fifty feet of the length of the groove, while the other half will remain as it is, beneath its protective covering of pebbles, gravel, sand, and mud, which acted as the graving tools in the firm grasp of the ice.

Originally a large area of this glaciated surface was exposed to sight. But in the progress of work upon the extensive quarry, the larger part of it has been removed. What is left, however, is ample for an object lesson. The portion of the groove preserved is thirty-three feet across, and the depth of the cut in the rock is seventeen feet below the line extending from rim to rim. Originally there was probably here a small depression formed by preglacial water erosion into which the ice crowded the material which became its graving tool, and so the rasping and polishing went on in increasing degree, until this enormous furrow is the result. The groove, however, is by no means simple, but presents a series of corrugations merging into each other by beautiful curves. When exposed for a considerable length it will resemble nothing else so much as a collection of prostrate Corinthian columns, lying side by side on a concave surface.

THE

AMERICAN GEOLOGIST

VOL. VIII. NOVEMBER, 1891. No. 5.

THE ATTITUDE OF THE EASTERN AND CENTRAL PORTIONS OF THE UNITED STATES DURING THE GLACIAL PERIOD.*

By T. C. CHAMBERLIN, Madison, Wis.

Aside from the inherent interest which lies in the determination of any general fact in geology, a special interest attaches to the determination of the attitude of the glaciated area during the ice invasions because of its bearing upon their explanation. I propose to discuss hypotheses of the cause of the glacial period in a separate paper; my present effort will be merely to set forth, somewhat synoptically, the leading phenomena, and the conclusions I draw, relative to the attitude of the eastern and central portions of the United States during that period. The special data appealed to have been gathered chiefly by the members of the glacial division of the United States Geological Survey, largely by Messrs. Salisbury, Leverett and myself.

I. Glacio-fluvial deposits of the lower Mississippi valley. The material of the lower Mississippi valley derived from glacial waters is divided into two sharply distinct classes; first and oldest, that which caps the bluffs of the Mississippi and mantles all the upland for 50 miles or more back on the east and which occupies the summit of Crowley's ridge that rises from the midst of the Mississippi bottoms in Arkansas. The second division occupies the trench in which the present bottoms lie and rises but

*Read before Section E, Am. Association for the Advancement of Science at the Washington meeting, August, 1891.

little above these bottoms, if at all, and is distinguishable from the modern fluvial deposits with difficulty.

The deposits of the first or earlier class are wholly silts, so far as determined by us. Our special investigations have been chiefly confined to the 150 miles next below the drift border, but they have reached, in a less consecutive way, to Mississippi and Louisiana. After careful and protracted search, renewed on successive seasons, we have entirely failed to find any coarse drift connected with glacio-fluvial formations that lie above the bottom lands, although the area is great and the exposure by gullying phenomenal. The "orange sands and gravels" which underlie the glacio-fluvial silts are non-glacial in character and seem to us to be demonstrably pre-glacial. At any rate, the absence of glacial pebbles, and even glacial sand and silt, from them removes them from any need of special consideration in this connection, even if they be supposed to be contemporaneous with the earlier glacial stages, for the absence of the glacial material may be taken as showing the incompetency of the upper Mississippi to bear such material southward at that time.

Silts being then the only demonstrable representatives of the glacial products borne south during the ealier stages of glaciation, it is a necessary inference that the land from the border of the drift to the gulf was so flat and so low that only slow-moving, silt-bearing currents were formed. The present current of the Mississippi is competent to carry coarse sand and small pebbles. The currents of the earlier glacial period were therefore less competent and the country was flatter than now.

Concerning the glacio-fluvial deposits that lie beneath the present river bottoms, or lie so low as to be indistinguishable from the fluvial deposits of the present river, little of a positive nature can be asserted. So far as known from borings and other evidences, they are not notably coarse. To the northward, in the glaciated region, they rise above the present river bottoms and have been traced back to their origin, so that we know the approximate attitude of the surface at the time that they were formed. They may therefore be set aside here and discussed later.

II. Phenomena of the Drift Border. The nature of the drif border in the axis of the Mississippi basin, where it reache fartherest south, is in itself significant of the attitude of the su

face at the time of its formation, if I interpret the phenomena correctly. The drift does not terminate in any well-defined morainic ridge, such as the ancient glaciers formed at several later stages. On the contrary, the termination is found in a gradual thinning out of the drift unattended by marks of forcible action on the part of the ice. The inference is therefore drawn that the ice crept out slowly upon a low slope, the gentleness of which accounts for the lack of vigorous action or forcible heaping of material.

This inference, which by itself might have but slight value, is supported by the fact that the sheets of till in this border region to a large extent graduate upwards into pebbleless clays and thence into loess-loams, or true loess, making it appear certain that slack drainage was a prevailing phenomenon.

This is further supported by the absence, in general, of coarse wash from the edge of these outermost drift sheets. At some points near the edge, but more commonly at points remote from it, there are beds of gravel, often taking a lenticular form, but these may be attributed to waters acting in channels in the ice or beneath it, where by confinement and by the peculiar conditions of glacial drainage they were forced to a vigorous action which they lacked when once they had issued from the border of the ice.

As a summary statement, it may be asserted that the phenomena of the border drift in the Mississippi valley present everywhere evidences of slack or slow drainage, with only such exceptions as may be rationally referred to enforced vigor through the immediate agency of the ice; and that there is nowhere evidence of powerful or specially rapid currents of water such as must inevitably have issued from the glacial border, in the axis of the great Mississippi basin, had the slope of the surface been at all considerable. It is therefore a firm and safe inference that at the time of the formation of the drift sheets that reach farthest southward there was no considerable slope of the surface; not even so much as now exists.

III. The Smooth Contours and Silt Aprons of the Older Moraines. In the axis of the Mississippi basin on account of the planeness of the surface and the great extent to which the ice stretched forward, the successive glacial stages are better deployed than in most regions east or west where later invasions overrode the territory of earlier ones and obscured the phenomena. The

region is therefore peculiarly fitted to the inquiry in hand. If we follow northward along the axis of the central ice-lobe in Illinois, we encounter, within about one hundred miles of the drift border, a broad ridge of drift, identifiable as a marginal moraine: and farther to the northward, similar ridges representing later stages of glaciation. The first eight of these bear common characteristics, all significant of the attitude of the surface at the times they were formed. They are all broad swells of gentle slope and smooth, though undulating, contours with the exception of a few local departures. They are not pushed into rough indented ridges, as is the fashion with terminal moraines forced up by vigorous glacial action. They appear rather to be the submarginal accumulations of a sheet of ice creeping gently down upon a plain of slight inclination. This interpretation, which in itself might be questioned, is supported by the significant fact that on the outer side of these moraines there are fringing belts of silt produced by the waters that crept over them while pressed on the inner side by the ice. These bordering silt-sheets terminate in and on the moraines and reach out to varying distances upon the plain to the southward.

It would appear, therefore, that we have in these phenomena evidences that cannot be gainsaid, that during the several successive stages that these moraines represent the attitude of the country was low, and that the drainage was more slack than at the present time.

IV. The Rugged Ridges and Gravel Aprons of the Later Moraines. The preceding phenomena represent the earlier and much the longer portion of the glacial period. But when, in coming northward along the Illinois river, we reach the moraine which crosses at Marseilles, and when, in ascending the Wabash river, we reach the moraine which crosses at Attica, we find a notable change in the phenomena. The moraine is not only more rough in contour and rugged in constitution but is accompanied by much more abundant evidences of wash and assortment in the form of gravel hills and gravel tracts. On the outside of the moraine, instead of aprons of silt indicating quiet overwash, there are aprons of gravel indicating more vigorous overwash. These fringing gravel tracts gather themselves somewhat promptly into the leading river valleys and flow down these in the trenches now occupied by these streams, which are cut into the older sheets of

drift. It is worthy of note that these trenches are cut through the older moraines and their overwash aprons of silt and are sunk down into them or below them. The later gravel-bearing floods ran at lower levels than the earlier silt-bearing waters; a clear demonstration of a change of attitude. It is clear from a study of these phenomena that at the time this moraine was formed the action of the ice was more forcible and the drainage more vigorous. The glacial waters ran away from the whole margin of the ice with measureable precipitancy, bearing coarse material. They gathered into definite channels previously cut in the older drift and ran along these at a rate which enabled them to carry gravel and sand far down their courses. Here we have for the first time in the history of glaciation, so far as now worked out on this the most favorable line on the continent for such study, an indication of an altitude and slope of the surface sufficient to produce vigorous drainage.

The question now becomes pertinent, how vigorous? How great a slope was indicated? On the Illinois river, overwash was sufficiently strong to spread out, on the outer side of the moraine, plains of gravel and sand of moderate degree of coarseness. Immediately next the moraine cobble stones of three inches in diameter are not uncommon. But only a few miles away from the moraine, even in the main axis of the gravel stream, the material becomes predominantly sand, the gravel becoming fine and subordinate. Near Chillicothe, for reasons not well understood, the material is again coarse but beyond becomes chiefly sand. On the Wabash similar facts present themselves. Within two or three miles of the moraine the deposit is chiefly fine gravel and sand and maintains this constitution far down the stream.

If I have correlated the moraines correctly, phenomena of the same kind and occuring at the same date are found on the Rock river, starting about twenty miles north of the Wisconsin line near Janesville; on the Wisconsin river in Sauk county, Wis., below its great bend; on the Chippewa river a few miles above Chippewa Falls; on the St. Croix river a few miles above its mouth; on the Mississippi river a short distance below St. Paul; and on the Des Moines river, at the city of Des Moines. Similiar phenomena also occur on all of the important tributaries of the Ohio and the Allegheny from eastern Indiana to northwestern Pennsylvania. In all

of these the facts are essentially the same; the wash was vigorous near the ice-edge and became less strong southward.

The slope of the glacial flood plain has been determined approximately in the most of these instances, and it is found that the descent was considerably more rapid than that of the present streams near the edge of the ice, but beyond that the descent was only slightly greater than that of the present streams. For instance, the terraces which represent the glacial flood plain on the upper Mississippi stand, at the mouth of Chippewa river, about 100 feet above the present stream. At the latitude of the southern line of Wisconsin, 150 miles south, the terrace is scarcely 50 feet high, indicating a slope of four inches to the mile more than the present. Between St. Louis and the southern extremity of Illinois the discrimination of the glacial flood plain from that of the present stream requires attention, as it only rises about 25 feet higher and is scarcely above the extreme reach of modern floods. Below the mouth of the Ohio it is not certain whether the glacial flood products under consideration have been successfully distinguished from deposits formed by the modern river. Declines of a similar nature are found on the Wisconsin, the Rock, the Illinois, the Wabash, the tributaries of the Allegheny and the Allegheny itself. On the Little and Great Miamis Mr. Leverett has found that the glacial flood plains descend less rapidly than the present streams.

But before conclusions respecting the slope of the general surface are drawn, it is to be noted that all these glacial streams were *depositing* and not eroding, and that their currents were not sufficient to enable them to carry away the burden of material furnished to them, so that they built up their bottoms until sufficient slope was gained. The deposits of gravel on these streams near the ice-margin, reach in several instances, beyond 100 feet in depth. The increased slope of the flood plain near the moraine is obviously due to the greater load of material and not to any upward curvature of the general surface.

These being the essential facts, judgment will perhaps differ as to the precise amount of slope which the general surface presented at the glacial stage in question, but I think no one, who duly considers the phenomena, will maintain that the slope was very much greater than the present. The existing streams are eroding their bottoms, even with their lower gradient, and th

glacial streams must have been very greatly overloaded with detritus to have been depositing streams, to the extent I have indicated, if their slopes were notably greater than the present, especially in view of the greater volume of water which the streams then undoubtedly bore.

V. Phenomena of the Latest Moraines. Within the outer moraine which bears this overwash apron of gravel are other and later moraines which present like phenomena, but in no case are they more striking, except locally and narrowly, and in most cases the overwash and drainage phenomena are more feeble. The moraine next succeeding is almost equally coarse and rugged in its development and is accompanied by almost equally coarse and abundant drainage drift, indicating the existence of about the same topographic conditions; but the later moraines generally display feebler drainage phenomena indicating a return to the flatter condition of the earlier glacial epoch.

VI. Lacustrine and Marine Phenomena. Contemporaneous with some of these later moraines and extending thence down to the close of the glacial period there was a succession of glacial lakes occupying the north-sloping basins. The presence of these lakes, the attitude of their shore lines and the position and character of their discharges indicate that low elevation prevailed during the closing stages of the glacial period. The same fact is proved more conclusively by the marine deposits on the Atlantic coast which were contemporaneous with the presence of the ice. The facts under this head are too familiar to require more than a passing reference here.

In the sketch thus far, I have followed the phenomena of the Mississippi basin because the drift is there deployed so advantageously and because its indications seem so conclusive, but the phenomena on the Susquehanna and Delaware rivers, as brought out by the studies of Lewis, McGee, Salisbury and others, as well as our own, testify to a like general fact, though in far less detail. The ealier glacial deposits there, as in the Mississippi valley, appear to have been accompanied by less vigorous drainage and to have been coincident with the submergence of the coast region. The later deposits were accompanied by somewhat more vigorous drainage than the present, precisely as in the Mississippi valley, but the glacial streams were there also depositing streams, and the phenomena do not seem to me to indicate

much greater slope of the general surface than the present, possibly no greater.

In the discussion thus far the *attitude* of the surface has been considered and a harmonious altitude has been assumed as a necessary factor. Abstractly it might be held that the whole region was lifted bodily without disturbing its flat surface attitude, but the drainage at the edge of such a plateau, formed of erodable material, like that of the lower Mississippi region would speedily revolutionize the whole drainage phenomena and the topographic aspect of the valley. It is utterly incredible that the silts that cover the west half of the state of Mississippi were deposited at even their present hight by a stream fifty, if not a hundred, miles wide. No such stream could exist on the brink of such a plateau of soft material, or, if once formed, could maintain itself for an appreciable fraction of the silt-depositing period. It is equally incredible that the broad trenches of the Mississippi and its tributaries could have been formed under plateau con-conditions. The whole phenomena show that low altitudes went with flat attitudes.

VII. General Conclusions. From this survey, which has necessarily been hasty and synoptical, since the details are multitudinous to the last degree, I draw the following inferences:

First. That throughout all the earlier stages of glaciation thus far determined in the Mississippi basin, the attitude of the land was lower and flatter than at present and the drainage slacker.

Second. That during the earliest stages of what I have been accustomed to interpret as the later glacial epoch, the attitude of this region was not far different from the present: possibly somewhat more elevated, and sloping somewhat more rapidly to the south, but the gradient could not have been very considerably greater than the present.

Third. That during the inter-glacial epoch the attitude of the country was such as to permit erosive drainage to the depth of one hundred or more feet below the present flood plains of the leading streams, but that the elevation of this period was not excessively great is inferred from the fact that the trenches so cut were broad as well as deep.

Fourth. That during the closing stages of the later glacial epoch the attitude of the country was again flat, being toward its close, more depressed than at present.

I invite attention to the fact that the area covered by these phenomena is broad both in longitude and latitude, and that it covers the larger part of the territory that has been critically studied with reference to such determinations. This territory is sufficient to constitute a large factor in any conclusions that can rationally be drawn respecting the attitude and altitude of the general area of glaciation of northeastern North America during the Ice age, and this area is the *great* area of glaciation and must form the central ground upon which the ultimate question of the cause of the glacial period, and the relationship of the altitude of the land to that cause, must be settled.

AN OUTLINE OF MR. MELLARD READE'S THEORY OF THE ORIGIN OF MOUNTAIN-RANGES BY SEDIMENTARY LOADING AND CUMULATIVE RECURRENT EXPANSION.

IN ANSWER TO RECENT CRITICISMS.

By T. MELLARD READE.

From the *Philosophical Magazine* for June, 1891.

INTRODUCTION.

It is now four years since the "Origin of Mountain-Ranges" was written, and during that time it has been subjected to considerable criticism by many able men in various parts of the globe. I have purposely refrained hitherto from answering any of the objectors to my theory, feeling that it would be better to wait and weigh them. It appears to me now that most of the criticisms primarily spring from an imperfect realization of its principles, scope, and details.

The misconceptions no doubt largely arise from the complex nature of the problems and the difficulty of keeping the various threads of the argument unravelled. Under these circumstances, I have thought that the best reply I can make is to restate in a shorter manner the various salient points of my theory. Probably, if I had given the theory a name, and properly christened my bantling before sending it forth in the world to seek its fortunes, I might have been saved from paternal difficulties.

To prevent further misconceptions, I now name my theory the "Origin of Mountain-Ranges by Sedimentary Loading and Cumulative Recurrent Expansion."

The outline here given is of the barest character, and for illustrations, details, proofs, and quantitative calculations I refer those who want to know more to the work itself, as also for those portions which deal with other theories, and are of a destructive rather than constructive nature.

Condition of the Earth's Interior.

The Earth a Solid Spheroid.

The latest mathematical investigations go to prove that the earth, taken as a whole, is solid, having a rigidity between that of glass and steel. The facts of physical geology are in accord with this view; for if the interior be wholly fluid, as some few contend, or if the nucleus be solid and the exterior shell solid with a zone of molten matter between, as others assume, the explanations of the physical conformation of the surface, its mountains and ocean-basins, become questions of flotation only.

The crust of the earth would be like a sheet of ice. This fact seems to me never to have been fully realized by those theorists who favor either of these views.

The Nucleus of the Earth possesses a high Temperature.

There is such a general consensus of opinion that the earth at a depth of from 25 to 30 miles below the surface is at a temperature equal to that of molten rock at the surface that it is unnecessary for me to go over the arguments in favor of this widely prevalent view. If we assume that it is so, a very little calculation will show that matter at the depth of say 30 miles is subject to an enormous pressure, to which we can find no parallel by experimental methods at the surface. Thirty miles = 158,400 feet; so that if we estimate that a column of the crust of the earth one inch square has a mean weight per foot of 1.5 pounds, the pressure at the depth of 30 miles will be in round numbers not less than 100 tons per square inch, or 14,400 tons per square foot. It has been proved by the experiments of the late Mr. Hopkins that there is in certain solids a relation between the melting-point and the pressure; so that, if the rock at the depth of 30 miles is at a temperature sufficient to melt it under ordinary pressures at the surface, the additional pressure of 100 tons per square inch may solidify it by raising its melting-point, or at least render it plastic. If the pressure increase more rapidly

than the temperature as the earth is penetrated, what may be only semi-solid at 30 miles may become rigid at greater depths.

These points, from their nature, are incapable of direct demonstration, but possess a high degree of probability.

Shell of Greatest Mobility.

Although not accepting the hypothesis that there is a fluid zone under the earth's crust, it would follow from the preceding considerations that the shell occupying the space between the solid rigid crust and the compressed rigid nucleus would respond to changes of pressure or temperature more readily than either the crust or the nucleus.

Facts of Physical Geology.

All great Mountain-Ranges are composed of great thicknesses of Sedimentary and other Deposits.

That all great mountain-ranges are composed of great thicknesses of sedimentary and volcanic deposits and igneous intrusions is a fact admitting of demonstration. It is true of the Alps, the Andes, the Himalayas*, the Rocky mountains or North-American cordillera, the Appalachians, the mountains of the Caucasus, and the Urals. The question at once arises in the mind, "Is this cause and effect?" If not, it is a coincidence somewhat in the nature of a miracle. If any one example to the contrary could be quoted, the argument of relation would be weakened, certainly not disposed of, but, so far as present knowledge extends, not one can be found.

---

*Mr. C. S. Middlemiss, in his extended criticisms on the "Origin of Mountain-Ranges" (Memoirs of the Geological Survey of India, vol. xxiv, part 2; Physical Geology of the Sub-Himalaya of Garhwál and Kumaun), calls in question this principle, though it is admitted by nearly all geologists since Dr. James Hall established the fact as regards the Appalachians in 1857. Quoting my words in the "Origin," "It is impossible to point to a range of mountains which has been built up of old denuded rocks," he completely misinterprets my meaning, which I had thought was plain enough from the whole tenor of the work. To give an illustration in the form of a prediction, I aver that no mountain-range will ever be built up out of any portion of the present land-area of Europe unless, and until, a basin of deposition has been established, and a thick sedimentary series deposited thereon. The old rocks may then be forced up along with the new, and form a constituent part of such a range. Unfortunately, as regards the Himalaya, information is meagre; but the granitic axes pointed to by Mr. Middlemiss as forming the highest peaks of the Himalaya are just what are required by my theory.

Sedimentary Deposits out of which Mountain-Ranges have been built up extend over Vast Areas.

The deposits out of which great mountain-ranges have been elaborated by foldings, intrusions, and up-heavals are not confined to the ranges and their immediate neighborhood, but extend over vast areas. Speaking generally, modern geological investigation goes to prove that the thickest deposits lie, or have lain, towards the axes of the chains, though they may have been denuded from the actual axes*. Beyond the more folded and disturbed portions of the chain which often, so far as the newer sediments are concerned, lie on the flanks, the strata take on more gentle curvatures until, as in the case of the Urals, the Appalachians, and elsewhere where observable, they become nearly horizontal, or only have dips due principally to faulting.

The Tertiary and Cretaceous rocks extend from the Alps to the Caucasus and across the Mediterranean to the African coast, and may lie far beyond, as little is known of the geology of that part of the continent. They reappear in the Himalayas, and may be

---

*Mr. Arthur Winslow, State Geologist of Missouri, in a paper just published in the "Bulletin" of the Geological Society of America, entitled "The Geotectonic and Physiographic Geology of Western Arkansas" (vol. ii. pp. 225-242), has applied the principles enunciated in the "Origin of Mountain-Ranges" to the explanation of an area in the Western part of the state tributary to the Arkansas river, 100 miles long in an east and west direction by fifty miles broad in a north and south direction. It is shown in an admirably concise and clear manner that the system of parallel interlocking anticlines and synclines having a general axial direction east and west is essentially Appalachian in character; that the Carboniferous strata of which they are composed increase in thickness from Missouri southwards into Arkansas; that the lateral movement has come from the South, and that the thickest strata are the most flexed.' Mr. Winslow shows—a point that I have strongly insisted upon as characteristic of anticlines—that these geological features are elongated canoe-shaped domes having quaquaversal dips. He considers that the expansion of the lower layers of rock produced by the rising of the isogeotherms and their consequent protrusion in the form of anticlinal cores has fractured the apices of the arches, and thus exposed the upper layers to energetic denudation. He infers also that the developed sections of such foldings are no measure of the original horizontal length of the beds—a principle I have strongly upheld, and which is being conceded by most geologists who have studied mountain-structure. The district seems to be one in which the first principles of the dynamics of mountain-building can be well analyzed, as there is not such a complexity of causes to be considered and discounted as in the more colossal disturbances of the great mountain-ranges of the world. A few careful studies of mountain physiography such as this by geologists who have the opportunity and are equipped with the necessary physical knowledge would be of infinite service.

continuously connected, though this has not yet been proved. The same formations extend far to the eastward of the Rocky mountains and the Andes, and most probably to the westward under the Pacific ocean.

The greatest ranges of the world have been elaborated in Cretaceous or Tertiary times, and the connection between sedimentation and upheaval is here most striking.

Sediments out of which Mountain-Ranges have been elaborated were laid down in Basins or Troughs formed by the bending of the earth's crust.

The thickness of the rocks, mostly conformable, composing some great mountain-ranges has been estimated by competent geologists at from eight to ten miles. The bulk of the rocks, as judged by their constitution, are usually considered by geologists to largely indicate either a moderate depth of water or actual shallow conditions. These rocks are intercalated with others exhibiting signs of a more oceanic origin. All the mountain-ranges mentioned may be pointed to in illustration of this statement. There is thus evidence that regional fluctuations of level in the earth's crust have taken place on a large scale often succeeded by, as in the case of the Coal-measures, continued downward subsidence combined with shallow-water conditions.

It is evident, from these facts, that the great earth-troughs, in which these materials for mountain-building were accumulated, were in some cases, on the final completion of sedimentation, double the depth of the deepest known oceanic troughs, which do not reach more than five miles.

Considering that there is a strong development of Cretaceous and Tertiary rocks extending along the western coast of North and South America, it is seen that these operations have there been carried on on an unusual scale. Deposit and alteration of level, elevation and subsidence, but preponderantly subsidence, progressed for an immense length of geological time in these areas, occupying not a mean portion of the earth's history.

It is not, however, to be assumed that this was a continuous trough at any one time, rather that it consisted of a series of connected basins which underwent independent changes of level, the area being part of the time low-lying land interchanging with conditions of submergence.

Volcanic action often contemporaneous with the laying-down of materials for Mountain-building.

Contemporaneous intrusive sheets of volcanic rock are a common occurrence in some part of the sedimentary history of a mountain-range. In addition, it is frequently found that volcanic ashes laid down in water, or subaerially, have a large development in rocks composing mountain-ranges; and necessarily, if these occur, dykes and volcanic rocks of the same age must exist in the foundation materials of the range.

Dynamical Principles.

Every theory which has hitherto been proposed to account for the elevation of mountains and the folding of the stratified beds forming the earth's crust hinges finally on changes of temperature. Thus the tangential force generated in a rigid crust of low temperature by the cooling and shrinking of the earth's nucleus has been invoked to account for the crumpling of the crust into mountain-ranges; the crumpled skin of a dried apple being the stock illustration. In this case, the force called in is *continuous* contraction by loss of heat. The theory which I have elaborated is one dependent upon *alternations* of temperature in the crust, contraction and expansion both being agents of uplift and lateral pressure.

Basins of Deposition and Loading of the earth's crust.

It has already been shown that the establishment of basins of deposition is the condition precedent to the building of a mountain-range. There can be no deposition if there is not land-area enough either in the shape of continents, islands, or active volcanic orifices, or all combined or successive, to yield the necessary sediment. This furthermore implies considerable stability of conditions over lengthened periods of time combined with local mutations and changes of level, and, as I have indicated, we have the history of these mutations within the rocks of a range. The distribution of sediments is dependent upon the depth of the water surrounding the land and the currents of the sea (when they are not laid down in lakes or subaerially by rivers); but, whatever the conformation of the coast and sea-bottom, a continuous discharge of sediment upon it must in time load it, and, as proved by the enormous thickness of rocks composing great

mountain-ranges, bend the crust below the maximum depth of any oceanic depression.

This necessary subsidence again insures the establishment of the basin of deposition and its continuous existence.

Displacement of matter in the Shell of Greatest Mobility.

If the matter in a shell of the earth between the nucleus and crust is in the condition I have postulated, it is evident that a lateral displacement of the matter of the shell must take place to some extent through weighting by sediment, and this will have its effect in raising the levels of the earth's crust surrounding the basin of deposition; but will not be an agent in mountain-building.

Movement of the Isogeotherms.

It is evident, from the variations in the rate of increase of temperature that exist in various localities as the crust is penetrated, that the lines of equal temperature (isogeotherms) in the earth's crust are subject to change, for it is not to be supposed that the temperature gradients have remained in their existing relations for all time.

It is also evident, as first shown by Babbage and Herschel, that the covering of any particular area of the earth with sediment will necessarily raise the temperature of the crust below*. If, therefore, we assume a thickness of 10 miles of sediment to be laid down in a basin of deposition or earth-trough, and the rate of increase of temperature to be one in fifty, what were originally surface-rocks possessing a surface-temperature determined by the climate of the locality will be raised in temperature over 1,000° Fahr., and eventually the whole of the underlying rocks of the earth's crust even below the shell of greatest change will be proportionately affected. The 10 miles of overlying sediments under such conditions would be raised 1,000° Fahr., at the base, diminishing to zero at the surface.

Effects of the rise of temperature on the Foundation Rocks. Initial Stage.

The section of the crust of the earth weighted and heated at the same time will be subjected to a gradually increasing compressive stress. So long as the actual expansive force of the heated crust is insufficient to raise the weight of sediment being

*This is well explained both by Babbage and Herschel in the 9th Bridgewater Treatise.

piled upon it, it will continue to sink, though subject to vertical pulsations of level due to other causes, which it is not my object to treat of here. But there will eventually come a time when the accumulated stresses of the expanding rocks will overcome the weight of sediment, and then the upheaval, folding, and building of the mountain-chain will begin. But it is not to be supposed that the rise of temperature takes place with the mathematical precision described here for mere purposes of explanation*. I have shown that volcanic action often contributes to the foundation materials of a mountain-range, and that intrusive sheets and dykes penetrate the sediments, and ash beds are laid down before the initial movement ushering in the birth of the range takes place. It is evident from this that there will be great variations of temperature taking place in the foundation crust and the sediments during their laying down.

The whole series of rocks, volcanic and sedimentary, will form a complex which will be simultaneously, but differentially, affected by the folding and elevation when that begins.

Unlocking the igneous forces of the earth.

When once the elevation initiated only by piling-up of sediment, the sinking of the crust, and its consequent heating—otherwise by the rise of the isogeotherms—is established, a movement of the interior heated matter of the earth must take place towards the axis or axes of the range. This is proved by the frequency of granitic cores in great mountain-ranges, by the volcanic action accompanying their elevation, and its persistence or recurrence in a range even late on in its history, as instanced by

---

*This seems a fruitful source of difficulty with some minds, beginning with Hopkins and ending with Hutton, Fisher, and Middlemiss. Their position seems to be this: if the rise of the isogeotherms into the new deposits eventually wrinkles and lifts them, why does it not begin at once? Why, for instance, should not 100 feet in thickness cause a rise, and if it does, how can thick beds ever be deposited? But there are thick beds, so the alleged *primum mobile* never acts. Q.E.D.

After making, as I fondly thought, full explanation of the *modus operandi*, I never anticipated the establishment of what a sense of humour compels me to call another *pons asinorum*. Even supposing the isogeotherms rose as rapidly as the deposits were laid down, the deposits could not be lifted until sufficient force accumulated to overcome the gravitation. But in a sinking area, as I have pointed out, if there be anything in the principle invoked, the presumption is that the isogeotherms are in process of sinking also, and it may take a lengthened period of sedimentation before they begin as a series to move upwards. There are many other possible conditioning causes. A practical mechanical mind should soon see through this imaginary difficulty.

he Andes, Rockies, and the mountains of the Caucasus, where olcanic cones surmount some of the highest granitic peaks, showig that these are the lines of least resistance through which the iterier forces of the earth expend themselves.

leating of the rocks of the Mountain-Range recurrent and constantly renewed during its history.

It is thus seen that the heated interior matter of the earth is onstantly being drawn towards and injected into the constituent ramework of a mountain-range. When once the elevation of he sediments consolidated into rocky matter in the earth-trough egins through the influence of lateral pressure and the expandig mass beneath, a reduction of pressure and increase of volume ıkes place in the underlying fused rock. The compressive tresses of the rigid rock are partially relieved by folding and pward flow, and the temperature of the mass falls. Additional ised matter has been drawn from the interior, and in process of ime the rocks of the range begin again to rise in temperature. uch fluctuations of temperature are well shown in the intermitent character of volcanic action. After a great outflow of lava, volcano is quiescent, sometimes for centuries. It has lost so uch matter and so much heat, but the forces accumulate uring the time of quiescence to burst forth with renewed vigor. uch intermittent activity I conceive is what takes place on a ırger scale in the history of a mountain-range, but with greater me-intervals.

Dynamical Effect on the strata of the crust by Rise of Temperature.

The effect of a rise of temperature on the rocks of the earth is, xcepting in the case of unconsolidated clays, to increase their ulk. From a great number of experiments made by me on ındstone, slate, limestone, and marble, I have estimated the coficient of expansion of average rock at 2.75 feet lineal per mile or every rise of 100° Fahr.: but there is every reason to believe iat the coefficient of expansion rises at higher temperatures than iose at which my experiments were conducted. It has been rged by some of my critics that I have not allowed for the comression of the sediments filling the earth-trough into denser iasses, but have credited all the expansion to mountain-building*.

*Hutton, Presidental Address, Section C, Melbourne Meeting of the ustralasian Association for the Advancement of Science, p. 89.

It has been overlooked that I have already explained that the weight of the mass alone will, by compressive extension, consolidate the beds below by reducing their thickness. Also the denser sedimentary rocks are often denser only by infiltration. This is particularly the case with sandstones, where the conversion into the final stage of quartzite is by the deposit of secondary silica in the interspaces of the grains, not by condensation.

Clays contract on heating; but, according to my views, the contraction of such beds in an earth-trough will be vertical only, by reason of the superimposed weight. A stage of metamorphism is at least arrived at, as we see in clay-slate, when the materials of that rock, originally clay, become metamorphosed so as to behave like other rocks, and expand with a rise of temperature.

Even if these criticisms possess much force, they do not apply to the rocky crust of the earth already consolidated forming the earth-trough in which the sediments are laid down. There will be little or no loss by condensation in them, only straining or change of form. It is obvious that deep-seated rocks must be so compressed by simple gravitation, that lateral pressure will have little effect in further condensing them.

Recurrent expansion cumulative in its effects.

If a given area of the crust of the earth is raised in temperature, when the limit of elasticity is reached the surplus material must be disposed of by a change of form; it will rise in the line of least resistance.

Assume that the surplus due to the cubical expansion of a horizontal sheet is thrown into a ridge, and that then a fall of temperature takes place to the same extent. The material ridged up can never be drawn back again; it becomes a permanent feature of the earth's surface. The contraction must be satisfied in another way, either by breaking up into blocks, faulting and subsidence extending through its substance, or by vertical contraction alone, and the lengthening of the beds by compressive extension due to the weight of superimposed materials. Probably both these principles generally come into operation together in nature. The earth is bound to retain its solidity in whatever way that may be satisfied. If a rise of temperature then succeeds, the effect will be as before, and deformation will result, its locality being determined by the line of least resistance.

In the case of a mountain-range it will take place along or

parallel to its axis, and the range will receive another accession of bulk.

Thus we see that the effect of alternation of temperature in the earth's crust leading to the establishment of mountain-chains is cumulative. This cumulative effect of small alternations of temperature may be seen in the ridging-up of any old lead gutter, lead flat, or lead-lined bath or sink. It has been likened to a "rachet" movement, which is not an inapt illustration if taken with the necessary qualifications.

EFFECTS OF CONTRACTION.—NORMAL FAULTING.

Normal faults, that is faults that hade to the downthrow, are the result of contraction, and are posterior to the first plication. Any section of a mountain-range traversed by normal faults shows the folds sheared in a way that proves this. Normal faulting is, however, most prevalent in the less disturbed strata that flank a range. The mountain-range pushed up by successive lateral thrusts or recurrent expansions acting over a great length of time and the folds thrown back and further compressed by the cores of gneiss and granite intruded into them, becomes a solid mass which cannot be drawn back by contraction. Contraction therefore has its maximum effect on the more horizontal deposits that flank the range, and extend for considerable distances on either side.

As the crust of the earth must remain solid, the condition is satisfied by shearing and wedging-up by gravitation,—otherwise by normal faulting. Contraction of igneous masses beneath may induce this faulting in some cases, but it is not a necessary condition. Cubical contraction of the solid crust is sufficient.

Answers to some objections.

The object of this outline of my theory is to focus its salient points, as many of my critics for some reason or other have failed to grasp them. What they criticise is frequently not my theory, but some rather vague notion called the "Herschel-Babbage" theory. What is exactly covered by this description I have a difficulty in ascertaining. On the other hand, one writer calls Mr. O. Fisher's theory, with which mine has no analogy, the "Herschel-Babbage" theory. I trust, I shall give no offence by repudiating this labelling and claiming the theory as my own.

Neither Herschel, Scrope, nor Babbage ever advanced so far as

to elaborate what could be justly called a theory of Mountain-building. They gave to the world some fruitful suggestions, and acute reasoning thereon, which have been of considerable use to a succession of speculators in geological physics, and to myself among the rest*. One of the most frequently urged objections to my theory is the supposed inadequacy of expansion by rise of temperature to account for the excessive folding some mountain-chains have undergone, linear expansion only being considered. My reply to this is that even linear expansion alone places at our disposal more lateral movement than any other theory. It is true that those speculators who have invoked tangential thrust through the assumed shrinking of the earth's nucleus, have had at their command any amount of lateral movement their imagination liked to draw upon, hence the simplicity and success of the theory—for a time. It has, however, been shown pretty clearly that the bank upon which these cheques have been drawn is one of very limited liability†, and quite unequal to honoring them.

Prof. Hutton, in his very able address to Section C of the Melbourne meeting of the Australasian Association for the Advancement of Science, gives an excellent *résumé* of the various hypotheses that have been suggested to account for mountain-building. I confidently appeal to his description to show that, omitting the theory of secular contraction of the earth's nucleus, which he disposes of very effectually, none of the suggestions, theories, or hypotheses except the one I support provides any lateral movement other than that due to intrusions of molten rock.

Prof. Hutton, in his description of my theory, doubtless given in the greatest good faith, leaves out what are in my view some of its vital and essential portions. I gave as an illustration the cubical expansion of an area of rock 500×500×20 miles, and showed that it would, if raised 1,000° Fahr., have an effective increase of bulk of 52,135 cubic miles‡. Prof. Hutton seems to assume that this is the ALPHA and OMEGA of my theory—the beginning and the end. I cannot but think it strange that he

---

*Until after my work was published I had read nothing of this but what was contained in Lyell's "Principles" and letters, and Babbage's paper, read before the Geological Society in 1834, nor had I read Scrope's views.

†See Hutton's examination of this theory in the Address referred to.

‡"Origin of Mountain-Ranges," p. 116.

should take this view, as one of the first chapters† details illustrative experiments to give the reader the first conception of recurrent expansion.

The fact is, that there is no limit to the lateral movement provided by recurrent expansion, excepting the natural limit of the number and intensity of the successive changes of temperature.

I can assure Prof. Hutton that if I had advanced no further than the single constructive conception of cubical expansion as an agent in Mountain-Building, in itself original—or, at all events, not contained in the Herschel, Babbage, Scrope, or Lyell conceptions of the effects of expansion on the earth's crust—the "Origin of Mountain-Ranges" would never have been written.

Conclusion.

The object of this outline being to correct some prevalent misconceptions of my views, I have confined myself principally to restating in a shorter form the essential principles of my theory of mountain-formation by sedimentary loading and cumulative recurrent expansion. For all the details, proofs, illustrations, and numerical calculations I must, as before stated, refer those interested to the original work. Perhaps it may lead some who have already read the "Origin of Mountain-Ranges" to again read and reconsider it, when I trust the points I have touched on in this outline will add to its lucidity. Honest criticism, even if severe, is one means of elucidating the truth, and I not only invite but welcome it.

Park Corner, Blundellsands,
Liverpool.

NOTES ON CAMBRIAN FAUNAS.

By G. F. Matthew, St. John, New Brunswick.

1. The Taconic Fauna of Emmons compared with Cambrian horizons of the St. John Group.

In view of the discussions now going on or that have been held, in regard to the vexed questions of Taconic and Cambrian, a few words of comment on this long imperfectly-understood and little known fauna, may not be considered out of place from one who has been at work on the lower palaeozoic rocks of a neighboring region.

Emmons' original types have at length been fully elucidated.

**Ibid.* Chap. III.

and to them have been added many species from Lower Cambrian horizons by various authors and especially of late by Mr. C. D. Walcott until we now have what seems to be a very formidable array of species. These are all classed together as the "Olenellus fauna", but there appears to be room for a considerable improvement on this general classification in the future, when the relations of the different groups of strata shall be better understood. To the writer it appears that there are indications of more than one horizon of life in the assemblage of forms that have been collectively designated the Olenellus Fauna. This appears to me to be indicated by the fauna of Washington county, N. Y., the source of Emmons' types, and which has been recently studied by Mr. Walcott.*

Until lately, and in fact until Mr. Walcott undertook this exploration, this fauna was so imperfectly known, that except as regards *Olenellus asaphoides* no use could be made of Emmons' discoveries for the exact comparison of faunas.

It is true that Mr. S. W. Ford pronounced *Atops trilineatus* a Conocoryphe, but without a figure and without knowing the sense in which he used the name no definite advantage came therefrom. This term Conocoryphe had been so loosely used in England and elsewhere that it had lost its generic value when cursorily used. Mr. Walcott's figures however enable us to see that *Atops trilineatus* is a true Conocoryphe.

In taking up the most prominent genera of this Washington county area one may begin with

Conocoryphe trilineata.†

This species is of especial interest as combining the head of a Conocoryphe with the pygidium of a Ctenocephalus. It is not a Ctenocephalus however, because the characters of the head shield should receive the first consideration, and these make it a Conocoryphe. As a Conocoryphe it should have but fourteen to sixteen segments in the thorax; the seventeenth segment in this species will represent the first segment of the pygidium of an

*Fauna of the Upper Taconic of Emmons in Washington Co., N. Y. C. D. Walcott, Am. Jour. Sci. Vol. xxxiv, Sept., 1887.

†The author fully agrees with Mr. Walcott that it would not be wise now to attempt to restore the name Atops for Conocoryphe as it would upset the nomenclature of the latter genus, largely used for more than forty years. Atops was not defined so as to be recognizable, either at the first, or for many years afterward.

ordinary Conocoryphe in which this segment is anchylosed in the pygidium, and not free as represented in *C. trilineata*.

Wherever known (except in this district of Washington county) the home of the Conocoryphea is in the Lower Paradoxides beds. This is the case in the south of France, in Spain, in Wales, and even in Sweden. In this latter country a species has been found in the Upper Paradoxides beds, but still the great swarms of these trilobites are found in the lower beds. This is also strictly the case in the St. John group.

*Olenellus asaphoides.**

The fact that this species is not intermingled at any locality with the Olenelli of Vermont, seems to me significant; and probably shows that we are dealing with a fauna of a different horizon from that where *O. thompsoni* and *O. (M.) vermontiana* occur. Had this species been found in a region distant from the two Vermont species, it might be regarded as a cotemporary regional variation of the type, but being so near at hand the probablilities are in favour of a difference of age between the Olenelli of the two places. *O. asaphoides* is the species whose development was so well shown by Mr. Ford, and by him compared to that of Paradoxides.

Microdiscus connexus.

This species shows points of close resemblance to those of the Lower Paradoxides beds. It is a composite of the characters of *M. dawsoni* of the St. John group on *M. eucentrus* of Sweden. Dr. Linnarsson in his essay on the Lower Paradoxides beds of Andrarum, gives a careful analysis of the layers which make up these beds, and of the faunas which they contain; and it may be seen that *M. eucentrus* comes from beds which by the contained fauna correspond to the highest of our Div. 1, *c* beds and the lowest of 1, *d*†. Thus the form appears to have shown itself a little

---

*This species was originaly described by Emmons as *Elliptocephala asaphoides*, and it appears to me now, that this name should have been retained; but I use the name by which the species is commonly known.

†For the convenience of those not familiar with the series of faunas found in the St. John group, the notation is given below:

Division 1 (Acadian).

- *a.* No fauna known.
- *b.* Fauna with Agraulos articephalus.
- *c. 1.* Fauna Paradox. lamellatus, c. f. oelandicus.
- *c. 2.* Fauna Paradox. eteminicus c. f. rugulosus.
- *d.* Fauna Paradox. abenacus c. f. tessini.

later in Sweden than in New Brunswick (Canada), as *M. dawsoni* characterizes the lower beds of Div. 1, *c*. But still the form in both countries is within the *Lower* Paradoxides beds.

Linnarssonia taconica.

Mr. Walcott speaks of this as a Lower Cambrian (*i. e.* Paradoxides beds) type, and says it is related to *L transversa* (of the St. John group) and *L sagittalis* (of the Menevian group). The resemblance to the St. John species, which ranges from Div. 1 *b* to *d*, is well marked.

Orthis salemensis.

This form may be compared with *Orthisina pellico* of the Paradoxides beds of Spain, and with *O.* (*c. f.*) *hicksi* of the St. John group. The latter is found in Div. 1, *c. 1*.

Leperditia dermatoides.

This agrees in form with an undescribed species from Div. 1 *b. 1* of the St. John group.

Without going into the comparison of other species of the Washington county fauna, which also resemble forms of the Paradoxides beds, it appears to the writer that those already mentioned prove a very close alliance between the Washington county fauna, and that at the base of the Paradoxides beds; and hint at the probable cotemporaneous or nearly cotemporaneous existence of the two faunas; not in the same area perhaps, but in districts not very far remote from each other.

As already remarked the partial independence of the fauna with *O. asaphoides* from that with *O. thompsoni* points to a difference of age between them. These are points which future investigation will determine.

To summarize the bearing of these remarks on the age of the

---

c. Upper Paradoxides beds, no fauna known.
Division 2 (Johannian).
a. Agnostus pisiformis,* supposed place of.
b. Fauna with Lingulella starri c. f. davidis.
c. Fauna with Lingulella radula c. f. lepis.
Division 3 (Bretonian).
a. Fauna with Parabolina spinulosa.
b. Fauna with Peltura scarabeoides.
c. Fauna with Dictyonema flabelliforme.
c'. { Black shales—Fauna unknown.
{ Place of Tremadoc (Ceratopyge) Fauna.
d. Fauna with Tetragraptus 8-branchiatus, etc.

**Agnostus pisiformis* is not found in the St. John Basin but further inland.

Washington county fauna, one may tabulate the range of the related species in the St. John group, as follows:

DIVISION 1 (ACADIAN).

Band.	b.	c. 1.	c. 2.	d.
Conocoryphe trilineata		x	x	
Olenellus asaphoides				
Microdescies connexus		x		
Linnarssonia taconica	x	x	x	x
Orthis salemensis		x		

The affinities of these species are thus as far as one can see with species of the Lower Paradoxides beds, both American and European, but we may also note that there are no species recognized as identical. This may be accounted for either by regional diversity, or by a slight difference of age.

THE SOURCE OF THE MISSISSIPPI RIVER.

J. V. BROWER, St. Paul, Minn.

Geographical discoveries in the state of Minnesota having been erroneously questioned and persistently misrepresented, the Minnesota Historical Society and citizens caused a detailed hydrographic survey of the Itasca basin to be made, and an exhaustive report thereon has been completed. Antedating the publication of the report, the following information is given in advance, for the information of those who desire the perpetuation of geographic facts and the truth of history, the same having been called for by his excellency, the governor of the State, and duly reported.

[COPY.]

MINNESOTA HISTORICAL SOCIETY,
ST. PAUL, Feb. 12, 1889.

To J. V. Brower, St. Paul, Minn.

SIR: Reposing especial confidence in your ability, integrity and good judgment, the Minnesota Historical Society, together with other similar societies who may unite with us for this object, does hereby appoint and commission you to make a careful and scientific survey of lake Itasca and its surroundings, with the view of determining, by a thorough examination of the spot, and of all its physical features, under all circumstances, what is the true and actual source of the Mississippi river.

We therefore request you to select such a corps of assistants as you may need to properly carry on such survey, and proceed to lake Itasca, prior to the opening of spring, to take the necessary observations with the above object.

On the completion of your survey you will please make a report to us of the result of your investigations.

On behalf of the Minnesota Historical Society:

HENRY H. SIBLEY, *President.*

[L. S.] J. FLETCHER WILLIAMS, *Secretary.*

[COPY.]

STATE OF MINNESOTA,
EXECUTIVE DEPARTMENT.

William R. Merriam, Governor of said State, to J. V. Brower, of Ramsey County, sends greeting:

Reposing especial trust and confidence in your prudence, integrity and ability, I have appointed you, the said J. V. Brower, as commissioner of the Itasca State Park, pursuant to an act of the Legislature of this State, approved April 20, 1891.

You are therefore by these presents appointed and commissioned commissioner of the Itasca State Park, as aforesaid, to have and to hold the said office, together with all the rights, powers and emoluments to the said office belonging or by law in anywise appertaining, until this commission shall be by me or other lawful authority superseded or annulled, or expire by force or reason of any law of this State.

In testimony whereof, I have hereunto set my name and caused the Great Seal of the State of Minnesota to be affixed at the capitol, in the city of St. Paul, this fourth day of May, in the year of our Lord one thousand eight hundred and ninety-one, and of the State the thirty-third.

By the Governor,

WILLIAM R. MERRIAM.

F. P. BROWN,
[L. S.] *Secretary of State.*

THE GOVERNOR'S REQUEST.

STATE OF MINNESOTA,
EXECUTIVE DEPARTMENT,
ST. PAUL, Aug. 3, 1891.

Hon. J. V. Brower, Commissioner of the Itasca State Park, 460 Jackson Street, City.

SIR: Publications in the papers of the state have been made within a few days past regarding the reputed discovery by a citizen of the State of New York of a new source of the Mississippi river, which he claims to have made in 1881, and has since widely published his right to be considered as its original discoverer, and causes changes to be made in the maps of our state in support of such discovery.

My attention has been called to these statements by citizens interested in the truth and correctness of the geography of our state, and it is desirable to have some definite and correct statement officially made as to

the hydrographic and other features of the Itasca basin, authorized by law to be set apart as a public state park, gained from a thorough physical knowledge of the same, to the end that facts regarding the ultimate source of the Mississippi river may be established and published for the benefit of the people of this state. I therefore request you to report to this department any facts in your possession which may be deemed pertinent to this question which has come to your knowledge as commissioner or otherwise.

Yours respectfully,

WILLIAM R. MERRIAM,

Governor.

THE COMMISSIONER'S REPORT.

STATE OF MINNESOTA, ITASCA STATE PARK,
COMMISSIONER'S OFFICE.

ST. PAUL, MINN., Aug. 13, 1891.

His Excellency, William R. Merriam, Governor of Minnesota.

SIR: I have the honor to acknowledge the receipt of your favor of the third instant, requesting me to report to your department any facts in my possession, as commissioner of the Itasca State Park, or otherwise, descriptive of the hydrographic and other features of the Itasca basin, authorized by law to be set apart as a public park, to the end that facts regarding the ultimate source of the Mississippi river may be established and published.

During the year 1889, as a special commissioner of the Minnesota Historical Society, a co-ordinate branch of the State government, I made a detailed hydrographic survey of the source of our great river, and formulated an exhaustive report thereon, which has not as yet been published.

From the field notes then taken, the correspondence, and all examinations and researches made, I have the honor to report the following facts for the use of the executive department of Minnesota.

The drainage basin of the Mississippi river extends from the gulf of Mexico, at the mouth of the river, to an ultimate limit above and beyond Itasca lake in this state. This great basin, more than 1,000,000 square miles in extent, is bordered on the east by the Alleghany and other ranges, and on the west by the Rocky mountains, and contains about 100,000 rivers and streams,

which flow toward and finally discharge their waters into the Mississippi, principally through the mouths of the larger and more important confluent and affluent tributary rivers. These waters are entirely supplied by the copious precipitation characteristic of the fertile basin drained from north to south by the Mississippi, as its principal and most important river.

To follow the proper rule in ascertaining, under commission, the true and actual source of this principal river, for geographic purposes, I consulted European and American geographers, scientists and authorities, gaining the following varied information as to what constituted the source of a river:

"That the main stream of a river is that which flows along the lowest depression of the basin, and that a tributary which descends into it from a higher elevation, even if longer, is not to be considered the main stream."

"A river cannot have a source but many sources."

"All our rivers have their source in the clouds."

(This authority does not say that the clouds emanate from the oceans of the earth, or whence came the oceans.)

"The head of the longest continuous channel."

"The sources of a river which are in a right line with its mouth, particularly when they issue from a cardinal point and flow to the one directly opposite."

Other authorities, some remote, and but a few reliable, suggest that the source must be a lake; must be the largest lake; should be the inner flanks of the hights of the land surrounding it; should be the source, because it was next to the historic pass, by which one river had, from ancient times, been left to reach another; because it was furthest from the mouth of the system; because it led down to the axis of the general valley of the basin; because it was at the head of the stream of largest volume; because it was geologically oldest, etc.

This widespread variance of authorities, good, bad and indifferent, gave me but little comfort in an interesting geographic and historic research, the source of no two principal rivers of the world being alike, and I arbitrarily adopted a reliable rule of no uncertainty, a rule of nature, in ascertaining where the waters were gathered which form the ultimate source of the Mississippi, and for that purpose the length of the main river in statute miles, up through the valley of the basin, was ascertained from the

official records of the United States government and otherwise, with the following result: .

	Miles.
From the gulf of Mexico, at the southwest pass, up the channel of the river to city of New Orleans....................	111.00
From city of New Orleans to mouth of Ohio river..........	965.50
From mouth of Ohio river to city of St. Louis.................	182.00
From city of St. Louis to city of St. Paul.....................	728.75
From city of St. Paul to falls of St. Anthony.................	13.00
From falls of St. Anthony to Winnibigoshish lake...........	432.50
From Winnibigoshish to range 36 west of fifth principal meridian*	96.50
From range 36 west of fifth principal meridian to foot of Itasca lake..	17.27
Total..	2,546.52

Thus it appeared that the main river of the Mississippi basin extends from the gulf of Mexico to the Itasca basin, a limited, permanent depression upon the surface of the earth at the ultimate source of the river.

The geologic and natural features predicating this conclusion are so well known and established that no reference to them seems necessary in this communication, excepting the possibility that the Missouri river, remotely suggested by occasional inquirers, might be called the main river; but inasmuch as it is a confluent branch of the main stream, coming in at one side, similar to the Ohio and Red rivers, I see no good reason for discussing that question at this time, nor do I deem it necessary to follow the historic data, however interesting, which has brought to our notice and knowledge the existence of the main river extending from the gulf to the Itasca basin, where it takes its rise, for there can be no well-founded disagreement as to that fact, because the discovery of the Mississippi, by piecemeal, is co-extensive with the discovery of the coast line of North America, and the facts are indisputable, in consequence of which I must base my reply to your executive communication upon the facts as they have been found to exist at and above Itasca lake, which has been for so many years recognized as the true source. To definitely determine those facts it became my official duty to ascertain whence came the waters of Itasca lake. This required a line of

*(The official surveys of the United States extend, upon the main river, only to the point where range 36 west of the fifth principal meridian intersects the channel of the river to and beyond Itasca lake. The fractional miles are taken from the record as it exists.)

levels in the field with the following result, to ascertain elevations above the sea:

	FEET.
Gulf of Mexico	0.0
City of St. Louis, above the sea	384.8
City of St. Paul	680.5
Above falls of St. Anthony (Minneapolis)	782.0
Below Pokegama Falls	1,248.0
Winnibigoshish lake	1,292.8
Cass lake	1,302.8
Itasca lake	1,470.7

The official reports of the United States government give the elevations to and including Cass lake, and an actual line of levels across the country from the railroad system of this state to Itasca lake, run by me in 1889, demonstrated its actual elevation above the sea at its outlet. The railway levels connect with the government levels.

With the distances and elevations thus ascertained, my survey of the ultimate source of the Mississippi river commenced in March, 1889, upon the frozen surface of Itasca lake, at the centre of the channel of the river, at its *debouchure*, from the extreme north end of the lake.

At a remote age the Itasca basin was the bed of one lake, now extinct, which I deem it a privilege to designate as lake Upham, and from this one lake, of unknown ages, by erosion, the waters probably having been increased by copious precipitation, cut their way through the ice formation and alluvial stratum to a natural condition of the river bed, as it now exists, immediately below Itasca lake. This process of nature, the waters passing to lower levels, has given us nearly one hundred lakes and lakelets within the Itasca basin, systematically divided apart, each of a different elevation, up the inner flanks of the Hauteur de Terre, surrounding the whole, from the summits of which the waters are returned to the oceans, through Hudson's bay and the gulf of Mexico, the Itasca basin itself being about seven miles long and five in width, and subsidiary to the main basin of the Mississippi.

The formation of Itasca lake is a small body of water at and around Schoolcraft Island, and three long, narrow arms projecting - one to the southeast, one to the southwest and one to the north -- from the last of which the Mississippi passes out from the lake. From the southeast and southwest extremities of the lake, picturesque valleys extend, denominated Mary valley and Nicollet valley, respectively, and up these valleys numerous lakes exist, each

at a higher elevation as you pass up the respective valleys than the one below, and each valley is drained by a running stream of perennial flowage, while at the side of the west arm Elk lake is situated, connected with Itasca by Elk creek.

Lines of measurements and of levels were run to and up through each of these localities.

The distances are as follows:

	FEET.
From the outlet of Itasca to the extreme southeast point at the mouth of Mary creek	22,639
Up the channel of Mary creek to Mary lake	3,658
Total	26,297
From the outlet of Itasca to the extreme southwest point at the mouth of Nicollet's Infant Mississippi	17,926
Thence up the channel to Nicollet's middle lake	8,513
Total	26,439
From the outlet of Itasca to the mouth of Boutwell creek	13,627
Length of Boutwell creek	8,700
Total	22,327
From the outlet of Itasca to the mouth of Elk creek	16,727
Up the channel of Elk creek to Elk lake	1,100
Total	17,827

These are the only streams entering Itasca lake worthy of any consideration. The volume of water, width, depth and flowage of these several streams were carefully ascertained, and the largest and most important one, at all times they have been examined by me, in 1888, 1889 and 1891, is Nicollet's "infant Mississippi river," which has been found to be the largest in volume of water and the larger and more important in every particular, with several perennial branches augmenting its prominence above the southwest limit of Itasca lake where it discharges its waters into the lowest in point of elevation of the several lakes there situated.

Selecting Mary valley and Nicollet valley as the two most remote water sheds within the Mississippi basin, the ordinary rules of hydrography were applied, and it was found that Mary valley contained the lesser ultimate reservoir and Nicollet valley the greater ultimate reservoir of the Mississippi system, each separate and distinct, drained by natural surface flowage. Then came the application of nature's common rule as to whence came the waters supplying the streams draining these two ultimate water systems at the source of the Mississippi.

It having been found that Nicollet valley contained the more important reservoir, supplying to Itasca lake the larger and the longer volume of surface flowage, I beg your indulgence in a minute description of this most remote and ultimate system in the great Mississippi basin, situated within the state park.

The perennial stream flowing down the inner flanks of the Hauteur de Terre to Itasca through Nicollet valley was discovered by Jean N. Nicollet in 1836. At the point where its waters flow into Itasca lake it was forty feet in width and two feet in depth at the date of my survey. Narrowing as you ascend the stream, it becomes three feet in depth a short distance from Itasca lake, with an increased current.

Passing up this interesting stream the explorer is impressed with its importance by its sharply defined banks, with its winding, meandering channel, deeply cut down into the stratum to a sandy, gravelly bed, with every appearance and characteristic of the Mississippi below Itasca lake. It has sandbars, sharp angles in its channel, deep and shallowing currents, and all the more striking features of a larger river. Large trees found near its banks incline toward the stream; a variety of fish, large and small, were found in its waters; the mink, otter and muskrat abounded, and wild ducks of many Northern varieties were from time to time noticed in its channel. Trees have been felled in several places across its banks to permit of passage on foot. Upon the removal of these trees, canoes might be propelled nearly two miles up this principal channel from Itasca lake.

These are a portion of the characteristics of the stream, indicating its permanency and importance, and, what is true of no other stream within the state park, it has three affluent branches flowing in from the hights of land to the westward, which augment its importance and permanency above any other stream found there.

These are Demaray creek, over one mile in length, Howard creek, nearly one mile in length, and Spring Ridge creek, each fed by numerous springs, sharply indicating artesian pressure from the lakes higher up the flank of the Itasca moraine. At Nicollet's middle lake is found the northern limit of the greater ultimate reservoir, with the Mississippi river flowing out from it toward Itasca lake.

My lines of level and measurements were continued from this point up through the trough of the reservoir to Nicollet's upper

lake, of doubtful existence, to the Mississippi Springs, Floating Moss lake, Whipple lake, the Triplet lakes, Morrison lake and Hernando De Soto lake, the last named being the most elevated and distant water from the gulf of Mexico within the Mississippi basin, exclusive of waters emanating from the summit of the Rocky mountains at the source of the Missouri.

Elevations above the sea at the greater ultimate reservoir are as follows:

	Feet.
Nicollet's lower lake	1,473
Nicollet's middle lake	1,474
Nicollet's upper lake	1,509
Mississippi springs	1,548
Floating Moss lake	1,561
Whipple lake	1,564
The Triplet lakes	1,568
Morrison lake	1,571
Hernando De Soto lake	1,571
Summits of Hauteur de Terre	1,670

The summits of the Hauteur de Terre (hight of land), immediately west of Hernando De Soto lake, divide the ultimate waters of the Mississippi from those of the Red river of the North.

The first surface flowage in the greater ultimate reservoir is a tiny brook connecting Whipple lake with Floating Moss lake. Down the incline from Floating Moss lake the Mississippi springs send forth a surface channel to Nicollet's upper lake, while three hundred feet west and twenty feet lower the channel again appears in a continuous surface flowage to Itasca lake, which is 9,200 feet to the north. It might be well to mention the fact that the head of Howard creek, a small and picturesque little stream with several miniature waterfalls, in connection with the infant Mississippi, constitutes the longest surface channel shown as follows:

	Feet.	Miles.
Gulf of Mexico to Itasca lake		2,546.52
Thence to the mouth of Nicollet's infant Mississippi	17,926	
Thence to head of Howard creek	11,126	
	29,052	5.50
From Gulf to head of Howard creek		2,552.02

Other channel distances are:

	Miles.
From the gulf to the head of Mary creek	2,551.50
From the gulf to the head of Boutwell creek	2,550.74
From the gulf to the Elk lake	2,549.90
From the gulf to the extreme limit of the greater ultimate reservoir it is	2,555.25
From the gulf to the extreme limit of the lesser ultimate reservoir it is	2,553.47

The great river having now been actually measured in its entire channel length by connecting surveys, the distances given, for the first time, are certainly more accurate than mere guess-work.

Since the greater ultimate reservoir is the extreme limit of the Mississippi basin, and the largest, longest and most important stream above Itasca lake takes its rise therein as a perennial surface drainage, I have reported the same to the Historical Society as the ultimate source of the Mississippi.

ELK LAKE AND ITS DISCOVERY.

In 1836 scientist and astronomer Nicollet laid down Elk lake as an estuary of Itasca, but since that time the alluvial stratum at the outlet of Itasca has been diminished by the constant flow of the water current until the latter lake has receded from the former to a lower level, and the two lakes are now connected by a short creek. The original discovery of this creek and of Elk lake must be awarded to Julius Chambers, who, on the ninth of June, 1872, while encamped on Schoolcraft island, explored the shores of Itasca, passed up the channel of Elk creek in his canoe to Elk lake, crossed to the southern shore of the lake, and, making a map of the lake, wrote:

"Here, then, is the source of the longest river in the world in a small lake, scarcely a quarter of a mile in diameter, in the midst of a floating bog, the fountains which give birth to the Mississippi." He found the lake much larger than he at first supposed. The world was notified by Mr. Chambers of his discovery in the columns of the New York *Herald*, page 8, July 6, 1872.

Mr. Chambers then passed down the Mississippi, from Schoolcraft island to the gulf of Mexico, in his canoe.

The next explorer to declare Elk lake the source was A. H. Siegfried, who, on the thirteenth day of July, 1879, reached the lake, and, taking a photograph of the same, declared it to be the "highest tributary to the Mississippi," in the columns of the Louisville *Courier Journal*, August, 1879.

The lake and creek were also visited in 1875 by Edwin S. Hall, in 1880 by O. E. Garrison, and in 1881 by Rev. J. A. Gilfillan. Whatever significance may attach to Elk lake as the source, Mr. Chambers must be awarded the honor of a first and original discovery, to the exclusion of all others, except Indians, known in our history, and the name "Elk," officially promulgated by the authorities of the United States, is the proper and legitimate

name for this body of water, acquiesced in by legislative enactment, and Elk creek takes its name from the lake. No one of the several brooks flowing into Elk lake are of any great importance, and all of them were completely closed with ice in March, 1889, and all of them were dry in August of the same year.

Geographic discoveries at and above Itasca lake prior to my survey in 1889, of authentic record, worthy of consideration and belief, are as follows:

William Morrison, first of white men	1803
H. R. Schoolcraft, Itasca lake	1832
Jean N. Nicollet, Five inlets	1836
Julius Chambers, *Elk lake and creek	1872
E. S. Hall, government survey	1875
Hopewell Clark, special survey	1886

Itasca lake is at the lowest depression of the basin and Hernando de Soto, Morrison and numerous other lakes are at the summit of the basin, and the water pressure from the lakes above Itasca, the whole being exclusively supplied by precipitation, causes a contributary inflow into Itasca lake, which is increased or decreased from time to time, according to the quantity of rainfall or duration of drought, as either may prevail.

One peculiar significance is demonstrated by the fact that Itasca lake has a flood plain of but little more than three feet in elevation above the natural surface of the lake. The flood plains of the lakes higher up are ten, fifteen and twenty feet. Thus, while Itasca lake is always supplied and sometimes rises during dry weather, the lakes at the summit dry down rapidly to a lesser surface area, depending upon rainfall to resupply them. During the summer of 1890, copious rainfall caused lake Itasca to rise a foot or more above Elk lake, and Elk creek flowed into, instead of out from, Elk lake. The outflow of lake Pepin, through which the Mississippi takes its course, is controlled by the inflow, and lake Itasca presents a striking similarity.

Infinitesimal deductions are necessarily drawn, however, from ascertained facts in order to discover the location of the ultimate source. Itasca lake lies at the pit of the basin and receives the waters discharged into it from summits surrounding it, which in return pass out into the channel below, forming the main water course of our country, to the gulf. Consequent inferences may

(*Elk lake and creek, discovered by Mr. Chambers in 1872, are constituted of waters erroneously claimed to have been discovered in 1881 by the person referred to in your communication.)

therefore be drawn by those who still believe that Itasca lake is the source of the river, it being situated at the pit of the lowest depression of the limited Itasca basin, but I know it to be a fact that there is a greater ultimate reservoir there at the summit, and it constitutes the ultimate source.

To prevent unauthorized, erroneous and deceptive changes in our state map, I suggest that a *resume* of the historical and geographical facts which led up to the final determination to locate the State Park at the source of our great river be included in my forthcoming report, and then, by legislative enactment, prohibit, within our own state, the illicit changes in the state map so assiduously persisted in from mercenary motives.

The law requires me to report a detailed chart of the park, and topographic field notes for that purpose will be completed in due time. The map accompanying this paper is reduced from that prepared for the Minnesota Historical Society.

Very respectfully your obedient servant.

J. V. Brower.

ADDENDUM.

The Itasca State Park contains thirty-five square miles, includes the territory shown in the accompanying map, is singularly picturesque in nature's abundant scenery, high hills and summits, pine and balsam forests and deep lakes prevailing.

The nomenclature, as far as completed, as directed by an order of the Minnesota State Historical Society upon a report of its committee, is as follows:

Omoskos (Elk) Sogiagon (Lake),	Ojibway.
Lac La Biche,	The French translation.
Elk Lake,	The English translation.
Itasca Lake,	From Ver-*itas-ca*-put. Schoolcraft.
Schoolcraft Island,	Named by Lieutenant Allen.
Infant Mississippi,	Named by Jean N. Nicollet.
Nicollet's Lower Lake, Nicollet's Upper Lake, Nicollet's Middle Lake, Nicollet's Valley,	After Nicollet.
Bear Point,	Named by Peter Turnbull.
Turnbull Point,	So called by residents.
Floating Bog Bay,	J. V. Brower's party, 1888.
Ozawindib Point,	After Schoolcraft's guide.
Garrison Point,	After O. E. Garrison.
Rhode's Hill,	After D. C. Rhodes, photographer.
Morrison Hill,	After William Morrison.
Island Creek,	Opposite Schoolcraft Island.

Mary Creek, Mary Lake, Mary Valley,	After Mary Turnbull, now deceased. She gave birth to the first-born of white parents at Itasca Lake.
Elk Creek,	Named by Committee.
Boutwell Creek,	After Rev. W. T. Boutwell.
Crescent Springs,	Crescent shaped.
Elk Springs,	Named by Committee.
Elk Pool,	Named by Committee.
Clarke Creek,	After Hopewell Clarke.
Siegfried Creek,	After A. H. Siegfried.
Demaray Creek,	After Morrison's daughter.
Howard Creek,	After Schoolcraft's daughter.
Mississippi Springs,	The Committee.
The Twin Lakes,	The Committee.
Danger Lake,	The Committee.
Ako Lake,	After Accault. A companion of Hennepin.
Josephine Lake,	J. V. Brower's party, 1888.
Sibilant Lake,	Form of the letter S.
Clarke Lake,	After Hopewell Clarke, by A. J. Hill.
Little Elk Lake,	The Committee.
Hall Lake,	After Edwin S. Hall.
Groseillier's Lake, Radisson Lake,	After first of white men to discover the upper Mississippi.
Floating Moss Lake,	The Committee.
Whipple Lake,	By Rev. J. A. Gilfillan after Bishop Whipple.
The Triplet Lakes,	The Committee.
Morrison Lake,	After William Morrison.
Lake Hernando de Soto,	In honor of the discoverer of the Mississippi.
Brower Island,	Named by the Committee.
Mikenna Lake,	Named by A. J. Hill.
Allen Lake,	After Lieutenant Allen.
The Picard Lake,	After Hennepin's companion.
The Lesser Ultimate Reservoir, The Greater Ultimate Reservoir,	Named by J. V. Brower, Commissioner.

Itasca lake was known as "Elk lake" prior to 1832. Surveyor General J. H. Baker, for the United States government, continued the name "Elk" to another lake in 1876.

The committee of the Historical Society was constituted as follows: Captain R. Blakeley, Hon. I. V. D. Heard and Hon. Charles D. Elfelt.

Upon submitting their report of names selected, the report was adopted.

The rule adopted by which to ascertain the source of the Mississippi proved most satisfactory and brought to the knowledge of the world the Greater Ultimate Reservoir, heretofore unknown to exist as such, although a portion of the lakes there situated have been known for many years, notably, Nicollet's lakes since 1836, and other lakes since 1875.

The discovery of Elk lake and creek was accomplished in the following manner:

Jean N. Nicollet, in 1836, found what is now Elk lake, to be a part of Itasca lake, as shown by his map now of record at the city of Washington, from which is taken the following:

NICOLLET'S SOURCE OF THE MISSISSIPPI, TRACED FROM OFFICIAL RECORDS AT THE CITY OF WASHINGTON.

After the lowering of the river bed at the north end of lake Itasca since 1836, Elk lake was left as waters gathered at one side, one foot higher than lake Itasca, and after the process of nature had separated the two bodies of water and formed a short creek, of no great importance, between the two, Mr. Julius Chambers was the first to discover Elk lake and creek, and he declared it to be "The Source" of the Mississippi, July 9, 1875, and to him must be awarded whatever honor is due therefor.

His map, first published by Ivison, Blakeman, Taylor & Co., is herewith reproduced, p. 305.

The report made to the Minnesota Historical Society by its commissioner was referred back for the purpose of having the same properly edited for publication, and the same is not yet published. When published, as a geographical and historical record, it will contain about forty-three chapters, the last three of which are yet to be supplied, descriptive of the formation of the State Park, and botanical and other observations.

The fact that formerly one large lake, with bays and islands and beaches, existed where now is found the several lakes at the Itasca basin, is beyond the inference of a mere conjecture, and to future explorers and geologists must be left the privilege and opportunity to locate its boundaries and determine its former importance; and until some further or more definite action, it has been designated lake Upham by Prof. Geo. B. Aiton and J. V. Brower.

The importance of the several streams flowing into lake Itasca in length, depth; width and flowage is as follows:

CHAMBER'S DISCOVERY.

First.—Nicollet's Infant Mississippi river, also called by him the "Cradled Hercules." Date of discovery, 1836.

Second.—Mary creek.

Third.—Elk creek. Discovered by Julius Chambers in 1872, when he declared it to be the Mississippi river.

Fourth.—Boutwel creek.

Fifth.—Island creek.

Sixth.—Creek at Floating Bog bay.

Seventh.—Small creek at extreme southwest point of Itasca lake.

Careful observers will note the importance of the greater ultimate reservoir, containing twenty or more lakes, at an elevation above lake Itasca. These lakes impregnate the earth with water and numerous flowing streams abound as a natural result, Itasca lake and Elk lake each drawing its supply from above with the following difference in peculiarity: Itasca lake receives all the waters flowing down from the summits, while Elk lake receives and discharges less than one-half. The creeks entering Elk lake are completely frozen in winter and have been found to be dry in summer.

EVIDENCES OF A GLACIAL EPOCH IN NICARAGUA*.

By J. CRAWFORD, Managua, Nicaragua.

None of the mountain ranges in Nicaragua rise to the altitude of the frost-line, and only four have peaks whose highest apexes are 6,500 (one 6,700) feet above the Pacific. The average altitude of the Cerros in this country is about 2,800 feet, and would not awaken a suspicion that any of these mountains had ever been deeply covered with ice. At the present time the night temperature on the summits of the Cerro Peña Blanca during the season when the trade winds are moving eastward, is frequently as low as 12° Cent., and occasionally 8° Cent.

The western or lake region of Nicaragua, the only part about the geology of which anything reliable has, until recently, been known, appears to have been formed of materials ejected from volcanoes which were active during all of the Quaternary, and at least parts of the Tertiary and of the Recent epoch†.

But we find *Pinus sylvestris* and some other cold climate conifers, dwarfish or attaining medium size, on some of the highest mountains of northern Nicaragua, and retaining, with some modifications, the distinctive features of their more northern types. In at least one valley of those Cerros is a large deposit of the petrified bones of Tertiary, and probably earlier period mammals and reptiles, as *Elephas*, *Ursula*, *Machairodus*, etc., and across that valley‡, at the foot of a cañon, are small hills, having long

*The publication of this article, received in March last, has been unavoidably delayed.

†I have not found "Miocene sands," "Miocene gastropods," nor other evidences of the Miocene in western Nicaragua, such as have been described by others as occurring there. See Proceedings of the Victoria Institute, 1876.

‡The valley of Sebaco, lat. 12 40 N., long. 85 58 W. The petrified bones are 50 to 100 feet beneath the surface, in sand and partly hardened sediment.

connected ridges composed, so far as examined, of irregularly mixed angular and rounded rocks of various sizes, together with smooth and rough-edged pebbles, clays and sands.

As we look from the valley of silicified bones, across the unassorted deposits, up the cañon, and along the sides of the mountains to the dwarfed pine trees growing between the rocks on the crest of the Cerros, we are led to inquire how and when these habitants of a colder climate were introduced to this half temperate, half tropical latitude, and when and how this cañon was excavated and the unassorted deposits were formed only a few miles beyond its lower end. The facts seem to indicate a greatly increased elevation and a much colder climate at some former epoch.

In 1889 and '90, during reconnaissance conducted for the government of Nicaragua, the writer discovered evidences which, taken in connection with others previously discovered, strongly indicate a Glacial epoch in this country, synchronous with that of the United States and Canada.

Some of these evidences are here presented.

On the top of the monogenetic series of mountains known in various parts of its extent as Cerro Yalli, Cerro Jenotega, and Cerro Peña Blanca, following an irregularly sinuous line from about lat. 13° 25′ N. and long. 87° W. to about 13° 30′ N. and 84° 55′ W.*, are several mesas, the largest, but not the highest, of which, is near the eastern termination of the series, and is named Mesa Turcos. The top of this mesa has an area of about twenty square miles of metamorphic rocks, granite or gneiss predominating, across which, and diverging nearly at right angles, are three shallow valleys, each about one mile wide. They begin near the centre of the mesa and gradually widen and deepen till they reach its nearly perpendicular sides. One, which extends southeastward, is the hydrographic area for the larger number of

---

*All these bearings are magnetic. This mountain system is south of that supposed to be referred to in Prestwich's Geology, edition of 1886, vol. I, p. 294, and designated "No. 25, System of Segovia. Cosequina and Cape Gracia-a-Dios." Cosequina is a volcano on a point of land which it has formed that projects into the Pacific ocean at the bay of Fonseca, and could never have formed part of the mountain system evidently referred to in the excellent work quoted. That system extends from lat. 13° 22′ N., and long. 87° 5′ W. *northeastward* toward the Gulf of Mexico and terminates about lat. 14° 50′ N. and long. 84° 52′, magnetic.

the head-water creeks of the Rio La Seibeta, whose waters, emptying into the Rio Tooma, and thence into the Rio Matagalpa, enter the Caribbean sea. Near the centre of this valley a cañon begins abruptly and deepens as we follow it for about three miles to the edge of the mesa, where it attains a depth of about 225 feet. The cañon is about 400 feet wide at top and sixty to seventy-five feet across its floor. The waters of a small creek, named Chomeha* which rises at the head of the valley, rush down over a few small cascades and falls, near the almost precipitous head of the cañon, to two vertical falls of considerable hight. At the first of these, the water drops about forty feet into a basin perhaps ten feet in depth and a hundred and fifty in breadth, formed in a flat granitic or gneissic ledge, and from this basin, through a channel about fifty feet long, a foot wide, and three inches deep, to the edge of the ledge, where it makes the second fall, or one of about 160 feet, into a basin in the metamorphic floor of the cañon. Flowing thence southeastwardly, the stream descends rapidly, often over falls and cascades, through the narrow rock-walled cañon, for about two miles, to a valley alongside of the Rio Seibeta. Along the sides of this cañon are many strange and beautiful forms of smooth-faced rocks, some projecting their oval surfaces for a few feet at right angles to the face of the cañon and extending for several yards parallel with its direction, others carved out into long intaglios. Above the falls and during the dry season, the stream does not exceed two inches in depth by fifteen feet in width, and its hydrographic basin does not embrace over five square miles. In that part of the valley are found many *moutonnéd* masses of granite and striated and polished masses and large flat loose rocks striated from one and a half to two inches deep in lines parallel with the flow of the creek.

Near the termination of the cañon in the lower or river valley, and extending across the valley to the Rio Seibeta, are several mounds and hills composed, so far as examined, of unstratified deposits of clays and sands containing rough and smooth-edged, large and small rocks and pebbles, indiscriminately mingled.

---

*Chomeha, as I learned from some old Indians of the Turcos and Amerrique tribes, is the name of a goddess of the aborigines, now sometimes invoked by the very small remnant of these once large Indian tribes.

From each hill there projects, in the direction of the Rio Seibeta, a ridge, apparently composed of the same materials as the hills*.

Another valley extends eastwardly from near the centre of Mesa Turcos, and is the head of the hydrographic area, whose waters flow through the Rio Tungla ("Princapulka," on the generally consulted but very incorrect maps, baileys, etc., of this country) into the Caribbean sea.

This valley also has a cañon cut out in it, the stream commencing in small cascades that continue in series for about two miles. Some of these series have a fall of from three to twenty feet. This cañon is cut down through rock for nearly two hundred and fifty feet before entering an elevated plain of oval-backed rocky ridges formed on the eastern boundary of the mesa. Smooth oval-surfaced areas and deeply striated masses of rock are frequently visible in and near the bed of the small stream which flows through this valley and cañon. Only a few scattered hills and ridges, but partially examined, were composed of unassorted deposits of boulders, rock-fragments, sand and clay, but these, in some parts of the ridges, were cemented together.

The third shallow valley on Mesa Turcos is the head of the watershed of several creeks which flow northward and then north-eastward through Rios Bokay and Segovia ("Wanx" or "Coco") into the Caribbean sea at Cape Gracias à Dios. At about a mile from its head, it divides into two cañons, in which, at short intervals, occur series of cascades. These cañons, like those previously mentioned, continue to increase in depth and width, having, where they leave the granite or gneiss and enter the highly inclined later strata, a depth of about 125 feet, and thence deepening until several hundred feet deep before reaching the lower foot-hills. The width of each cañon, while in the granite, is at top about 200 feet, and across the bed about forty feet, increasing locally to seventy or eighty. In the later formations, they widen rapidly, maintaining nearly perpendicular walls, and their channels resolve into labyrinths of passage-ways between numerous columns and smooth-edged boulders some fifteen feet high, so intricate that, during an examination made, accompanied by two Indians, in one of these labyrinths, several passage-ways were unsuccessfully attempted and much time was lost in trying to get

*Doubtless these would be designated "moraines" in Minnesota, New York, or Canada.

out of the place. Both cañons, in their northeasterly extension, obliquely bisect two "lodes," respectively eight and twenty-one feet wide, of westwardly strike, dipping at an angle of about 35° (megnetic) north, and containing gold, sulphides, and arsenates in a gangue of fragments of quartz, talco-slates, chlorite slates, iron-clay slates, etc.; the walls are diorite and diabase. About one hundred miles to the northeastward is a deposit of colored marbles, intersected by the Rio Segovia, and about the same distance eastward and fifteen miles north of the Indian village of Wylo-was (on the Rio Tungla), is the southeastern end of the rich gold placers of Princapulka, terminated by a small cerro of Carboniferous limestone*.

On the Pacific ocean side of the dividing range of Cordilleras in Nicaragua, the mountains terminate in a large mesa, named Totumbla, whose summit area embraces about nine square miles: and across this, from north to south, is a shallow valley about two miles wide on which are exposed at several places large masses of rock having smooth rounded surfaces, and measuring fifty to two hundred feet long. Some of these masses are polished. Near the edge of this valley are numerous flat, striated boulders and loose striated rocks of local origin. The most numerous striæ are parallel with the general direction of the valley. The locality of this mesa is about lat. 12° 42′ N. and long. 85° 55′ W. Its altitude above the Pacific ocean is 3,260 feet. It is composed of gneiss and other rocks of the Eozoic series—all metamorphosed. On the margin of the summit-plane of this mesa are many peaks fifty to two hundred feet higher than that plane and connected nearly continuously by high ridges. On the inner

*The generally superficial examination of this Mesa Turcos, the valleys at its sides and on its top, and the deep cañons, was not easily made. This locality is fully one hundred miles from any human residence and in a dense, pathless, mountainous forest. In the valleys the vines and bushes were often so thick as to require cutting, step by step. Consequently we could take but very few tools, ropes, instruments, etc, witl us, and all our provisions were carried on the backs of Indians. Th scenery (when twice only we found mountain peaks with forests s thin that we could get a long wide vista) is almost incomparably beaut ful. In some places on the sides of the cerros and in the lower valle groves of tall, large mahogany, sapote, nispero, Spanish cedars, walnu and liquidambar trees, standing as living columns encircled with vin are covered with their own bright foliage, and with vines, mosses, epiphyllous flowers; while at other places orchids and ferns and flov ing plants or bushes, in great variety are numerous and some of tl very large.

or table-land side of one of these peaks, on the northwest margin of the mesa, there nearly precipitously begins a cañon in the gneiss 1,100 feet deep and about 1,500 feet wide at top and fifty to one hundred across its usually dry bed. Near the head of this cañon and about 320 feet below its ridge-like upper margin, is an oval-roofed cavern three to six feet high, eight to fourteen feet wide, and extending into the rocky side of the cañon in a direction perpendicular to the cañon's axis for over two hundred feet. This is a laccolite, having one of its ends broken or eroded off and this open end obscured by loose rocks. Access to it down from the top of the mesa or up from the bottom of the cañon is very difficult. This cañon enters the valley on the mesa about one mile from its southern margin and then descends in falls, cascades, and rapids over the steeply inclined side of the mountain to the valley of the Rio Veijo. For about the first two miles of its length, there is no water, save in the brief rainy season. The small stream in the valley into which this cañon enters flows through or down the Rio Veijo into lake Managua and thence through lake Nicaragua and the Rio San Juan del Norte into the Caribbean sea, thus forming in its route an arc of about two-thirds of a circle and of several hundred miles, instead of flowing westward from the mouth of the Rio Veijo, through a flat country, into the Pacific ocean. At the lower end of this cañon, as it enters the valley of the Rio Veijo, are numerous hills and knolls, many of them having long connected ridges that extend far into the valley. Those examined, and probably all of them, are composed of irregularly mixed, unstratified rocks, clays, pebbles and sands, cemented in some places by iron oxides and elsewhere but partly hardened. Across this valley, in a crescent formed by the Rio Veijo, is the large deposit of petrified bones of Cenozoic (and possibly some of them Mesozoic) mammals and reptiles previously referred to in this paper.

Between the town of Ocotal and the village of Depilto, eight miles distant from each other, in the Department of Nueve Segovia, at about lat. 13° 35′ N. and long. 86° and 32′ W.: are found such apparent evidences of glaciers' work*, as striated

*The late Thomas Belt, F. R. S., in his "Naturalist in Nicaragua," second edition, declares these to be moraines and considers them indisputable evidences of a Glacial Epoch here. When I made the examination of that locality I did not know that he had previously been there.

boulders, deposits of sands, clays, pebbles, and rocks, generally appearing to be unassorted; but in some parts they appear stratified, not as deposits made by recent floods, having well defined lines of separation, but as if made interruptedly and at the same time with the other large masses of (so far as examined) unassorted deposits. These moraines* are at the confluence of the three rivers, Segovia, Depilto and Maculeso whose aggregate hydrographic area is about eight thousand square miles. My notes, made after several examinations at intervals during a stay in that part of Nicaragua of about four months, state that possibly a large portion, if not all, of these deposits are moraines.

Several large knolls and small hills are found north of the village of San Rafael del Norte, in the department of Matagalpa, at the southwestern foot of the Cerro Yalli, about lat. 13° 20′ N. and long. 86° W., each having extensions of from one hundred and fifty to six hundred yards long, declining into the Rio San Rafael del Norte, composed, so far as my examinations extended, of the unassorted, unstratified fragments of rocks and pebbles, some rough, others smooth-edged; all embedded in sands and clays. In some places the clays, in others the sands are in excess. These deposits were first discovered by the late Thomas Belt, F. R. S., and described in the second edition of his "Naturalist in Nicaragua," published within the past few years in London. He declares them to be moraines, which if discovered in Canada would unquestionably be so considered. Cerro Yalli, at this locality, is tall and has steep sides, but the hydrographic area is comparatively large, and although I found no narrow, deep ravines in the side of the mountain near these deposits of un-

---

I believe it was his only trip (and one of only a few days) to this locality, distant for more than three or four leagues, from the mines near LaLibertad (that he superintended for a few years). He was a quick and close observer, but was hurried on this trip and did not note, probably, the large hydrographic area of the three rivers, Segovia, Maculeso and Depilto which unite, in this locality, their rapid currents.

*I had doubts about these being moraines, until two months ago, when for the first time and only for a few hours, I had opportunity to examine the work of the late Thomas Belt, referred to in foregoing note. I believe Mr. Belt was correct in designating these deposits moraines. My doubts occurred because we are sometimes liable to mistake deposits made by water for those made by ice, unless after extensive excavations, etc.; also, because the water-shed of these three rapid rivers is quite large, and in flood times they transport large boulders for long distances, and, because there are evidences that a part, if not all, of that valley has been overflowed.

stratified materials, yet I could not persuade myself that the rocks, pebbles, clays, sands and pieces of lignite composing these hills, knolls, and ravines had been transported to and deposited in this valley by water. I found, it is true, many loose boulders at various places on the side of the mountain, too many, I thought, to remain in such places after a glacier had moved over them; but, possibly those boulders were deposited by some melting ice-sheet.

Other evidences in the Nicaragua of a Glacial epoch, subsequent to the Pliocene, have been discovered and examined by me, but none found to be so distinct and impressive as those herein described.

Hydrographic charts, made by both the U. S. Coast and Geodetic Survey and the British Admiralty, of soundings of the Caribbean sea, from the coast of Nicaragua east to the Atlantic ocean, show (besides the bed of one, or possibly two, old lakes or inland seas whose present beds are 1,000 to 1,900 fathoms below the present surface of the sea) long, deep, wide holes in the bed of that sea, at intervals from the principal (really the old Pliocene or ante-Pliocene rivers) mouth of each of the Rios Escondido (Bluefield), Matagalpa (Grande), Tungla (Princapulka) and Segovia, which holes are traceable eastward to the western margin of the Atlantic ocean, or to about 60° west longitude on the east side of the Antilles, indicating that the channels of these rivers once extended out fifteen hundred miles further than at present. These sub-marine fiords are now nearly filled up by debris of brachiopods, cephalopods, mollusks, etc., and in the shallow parts by corals. The average depth of this sea is about 5,500 feet, but if we consider the two very deep places as lakes existing in the early Tertiary period, then the average depth of the Caribbean sea is less than 5,000 feet, or, less in depth than the altitude at present above its upper surface of several cerros in Nicaragua. The deep holes in apparent continuation of the former channels of some of the old rivers that emptied from Nicaragua into the Caribbean sea indicate, in connexion with the facts related in the foregoing part of this paper, that *great elevation once occurred in that latitude* and *locality* sufficient to have raised, far above the surface of the water, almost all of the bed of the Caribbean sea, and to have extended the mountains in the central part of Nicaragua far up into zones of snow and ice, producing a Glacial

epoch. There are atolls and barrier reefs in that sea, which, in all probability, are continuations by corals, upward, at the rate of sea-bed depression, or subsidence of the tops of mountains that now are the sub-marine, but once were the sub-aërial parts of the Nicaraguensian continent. When elevation had completed its work here, it is probable that subsidence deeply submerged the present Isthmus of Panama.

No river flows from the deep, concave western side of Nicaragua into the Pacific ocean of sufficient size to be considered a factor in connection with this subject.

The foregoing facts indicate:

(a) That, at least, two or three mountain ranges in Nicaragua were deeply covered by ice during a Glacial epoch contemporaneous with that which existed in the North American continent.

(b) That at that time there was, because of great elevation of land and sea-bed, a Nicaraguensian continent extending eastward, about fifteen hundred miles further than at present, over the northern and middle part of the area now occupied by that part of the Caribbean sea eastward from the Nicaragua coast, to the Atlantic ocean at about the 60th meridian west from Greenwich.

(c) It is probable that the submergence of the Isthmus of Panama was then sufficient to allow a large part of the south equatorial current (which now carries so much heat to northern latitudes) to pass into the Pacific ocean.

(d) Cosmic conditions, as irregularity in the amount of heat from the sun, equinoxial precessions, variations in the excentricity of the earth's orbit, and extreme variations of the magnetic north and south poles, may have been factors; but the two latter were certainly of very moderate effect in producing a Glacial epoch. Great elevation of land appears to have been the potent cause in Nicaragua.

(e) The movements of elevation and subsidence appear to have been more rapid in this country, than in latitudes many degrees further north, and more frequent and vigorous in Glacial and Recent times.

(f) It is quite probable that the extensive fracturing and fissuring during the early Glacial or late Pliocene epoch gave rise to several additional volcanoes along the western part of Nicaragua and added variety to the scenery of mountains clad in ice in the central part.

ON CYCLES OF SEDIMENTATION.

J. LAWTON WILLIAMS, Hornellsville, N. Y.

The fact of cycles of sedimentation is well known to stratigraphical geologists. The following table, from Dr. Alexander Winchell, is a good illustration of what is meant by the term:

TABLE OF CYCLES OF SEDIMENTATION.

Palaeozoic Systems	Coarse Fragmental.	Fine Fragmental.	Calcareous.	Calcareo-Fragmental.
Upper Carboniferous.	Parma Conglomerate.	Coal Measures. (Broken into small epoch.)	Laramie Limestone.	Permian.
Lower Carboniferous.	Waverly Sandstone (Marshall Phase.)	Waverly Sandstone (Chouteau Phase.)	Mountain Limestone.	False Coal Measures.
Devonian.	Oriskany Sandstone.	Schoharie Grit.	Corniferous Limestone.	Hamilton and Chemung
Silurian.	Medina Sandstone and Oneida Conglomerate.	Niagara Shale and Clinton.	Niagara Limestone.	Salina.
Cambrian.	Potsdam.	Calciferous and Chazy.	Trenton Limestone.	Cincinnati.

While these divisions may be somewhat artificial and arbitrary, they seem to illustrate the general fact of a definite sequence in sedimentary deposits. Similar relations have been observed in the strata of Great Britain. Mr. Hull (Quart. Jour. Sci., July, 1869,) makes a triple rather than a quadruple subdivision: 1st, a lower stage of sandstones, shales and other sedimentary deposits, representing prevalence of land with downward movement; 2d, a middle stage, chiefly of limestones, representing prevalence of sea with general quiescence and elaboration of calcerous organic formations; 3d, an upper stage, once more of mechanical sediments indicative of proximity to land.

The identity between this and Winchell's table is apparent. In both we may begin with a given stratigraphical structure, and, after passing through a definite succession of intermediate structures we again encounter one like the first. We are to bear in mind, however, that this succession is not a rigid one. Oftentimes we meet with intercalated beds which have no representatives in the other members of the series. Besides, there are wide

variations in the relative thicknesses of analogous beds, and in the aggregate thicknesses of different cycles. The facts with which we are impressed, however, are not the minor discrepancies and apparent anomalies, but the broad general fact of a definite sequence. And the conviction becomes irresistible that such a sequence, must be referred to a periodical recurrence of certain fundamental phenomena concerned in the evolution of our planet. These phenomena may be considered under two heads in relation to this subject: 1st, immediate causes; 2d, remote causes. The immediate causes are evidently, (a) the elevation and subsidence of land areas, (b) meteoric conditions affecting the rate of erosion of these areas (c) the mutual reactions of these separate forces. In the remote causes we must seek for an explanation of the *periodicity* of upheavals and subsidences. It is clear that with a given surface of the earth's crust, an elevation of a portion of land must either result in a depression of some other portion of land or of the sea bottom. Let us suppose an elevation of land to take place which results only in a depression of the sea bottom. There will then be a smaller surface of the waters of the globe exposed to the evaporative influence of the sun. Other things equal, there will, consequently, be a diminution in the amount of precipitated moisture. This will necessitate a diminution in the amount of erosion and atmospheric disintegration of the emergent areas, provided the rainfall be equable. But the amount of erosion depends not only upon the quantity, distribution and periodicity of rainfall, but also upon the angle of slope of the land subject to erosion. The effectiveness of erosion varies directly as some high power of the velocity of the eroding fluid, and the velocity is a direct function of the sine of the angle of slope. So that the diminished precipitation due to a diminution of the water surface might be more than counterbalanced by a disproportionate increase in the angle of slope, in the final results of erosion. Let us assume that in a given instance this was actually the case. Then the great angle of slope would necessitate a precipitous fall of torrents. Suppose the slope is such as to double the mean velocity of a given volume of water falling in a given interval of time. Then, whereas formerly this same volume of water transported to the sea fragments whose dimensions may be represented by 1^6 or 1, now it will transport fragments of 2^6 or 64, since the transporting power of a fluid varies

as the sixth power of the velocity. (Hopkins Q. J. Geol. Soc. VIII p. 27.) These last will have a size relative to the first as small cobble-stones to gravel. Now let us suppose the process of erosion continues. The coarse fragments will be polished and rounded by their journey to the sea, and will be deposited in a soft matrix of mud and finer pebbles as a conglomerate. The largest fragments will be deposited first, and, with the wearing away of the slope, and consequent diminution of the angle of slope, the size of the pebbles of successive deposits will be smaller and smaller. Finally, when the angle of slope becomes such that the velocity is one-half what it was at first, the size of the fragments will be 1 instead of 64. Such fragments will become a sandstone or shale according to circumstances. At length the land will be entirely eroded away. Meantime the sediments deposited along its shores will have accumulated to a vast depth. This accumulated weight will necessitate a submergence to restore the equilibrium of surface pressures (Babbage and Prof. Jas. Hall). The deposits will sink to a depth which will be congenial to the development of vast populations of corals, crinoids and other lime-secreting organisms. Here they may continue to build through a long succession of generations, the increment of weight due to their accumulation producing just enough submergence to maintain a proper level for their growth (Darwin). A vast deposit of crude limestone will be the result. This is precisely the succession found in the table at the beginning of this article. Conglomerate, sandstone and limestone are repeated over and over again. In the preceding discussion we have assumed the simplest conditions imaginable: an eminence of land, a given elevation subject to no oscillations of level during the long period of time while it is worn down to the level of the sea, an equable and uniform quantity of precipitation, and a sufficient weight in the accumulated sediments to effect a subsidence when the destruction of the land was completed, and, finally, a subsidence deep enough and not too deep to be favorable to the growth of lime-secreting organisms.

It is astonishing to see how faithfully these ideal conditions have been repeatedly realized as recorded in the Palæozoic rocks of North America. And it is perfectly conceivable how a variation of these ideal conditions might lead to the discrepancies and anomalies already alluded to. We

assumed a uniformity of meteoric conditions, but such a uniformity is impossible from the very nature of the other conditions assumed. For when the land has a great elevation the moisture precipitated upon it will assume the form of snow and ice which will inaugurate various climatic changes. As the land is worn away there will be a greater surface of water exposed to evaporation, and this will react upon the quantity of precipitation. Again the disappearance of land will allow oceanic currents to pursue new channels which will directly react upon climate and indirectly upon precipitation. Finally the land will in most cases be subject to oscillations of level which will react upon climate in a complex and indirect way, and upon the rate of sedimentation in a direct way. Any one of these variations will interfere with the uniformity of the cycle, and when several of them are concerned simultaneously it will be correspondingly complex. So much for the immediate causes. In the remote causes we must seek for an explanation of the *periodicity* of upheavals and subsidences which have given rise to cycles of sedimentation.

For our present purposes it will not be necessary to enter into a discussion of the causes which have determined the existing configuration of land areas. Without doubt, Prof. Darwin's appeal to astronomical influences suggests a general explanation of the leading facts. Also Dr. A. Winchell shows (World Life) how the lunar tides during the earth's early incrustive stages would impress meridional lines of weakness. The subsidence of the earth's equatorial protuberance due to the secular diminution of its rotational velocity would conspire to a like result. When such lines of weakness are once established every contraction of the crust due to the radiation of internal heat will give rise to rugosities along those lines, and these rugosities once established will tend to grow with every increase in the lateral pressure. So much for the generalities. But there are certain special and very remarkable phenomena which these hypotheses do not take into account. Such are the periodicities of upheaval and subsidence which have given rise to cycles of sedimentation. Mallet has argued in another connection that the contraction of the earth's crust due to secular cooling would by the crushing of the rocks give rise to an enormous quantity of heat, and that this crushing would take place after long intervals of quiet, during which intervals the tension necessary to produce the crushing would be generated.

Doubtless here is one explanation of the periodicity of disturbances in land areas. There are others. Dr. Croll has shown how the precession of the equinoxes combined with variations in the eccentricity of the earth's orbit must give rise to a secular recurrence of periods of refrigeration. When winter in one hemisphere occurs in aphelion and the eccentricity is a maximum, the polar regions of that hemisphere will be covered with a cap of ice, and a climate of arctic severity will prevail. Meanwhile the other hemisphere, beyond the equator, will have a torrid climate. This state of affairs will continue until the precession of the equinoxes shall reverse the conditions. Then the other hemisphere will suffer refrigeration and a tropical climate will dispel the ice-cap from the first. Dr. Croll shows how these changes would cause a shifting of the earth's centre of gravity toward the pole which sustained the ice-cap, and thus the oceanic waters would rise on that hemisphere and deluge the land. Thus each hemisphere would undergo alternate phases of submergence coincident with the alternate periods of refrigeration. This oceanic oscillation, Dr. Croll argues, accounts for the alternate beds of coal and shale so characteristic of the Coal Measures in all parts of the world. (Climate and Time.) Here then we have another clear cass of periodicity. I would add in this connection that movements of the internal fluid arising from changes in the center of gravity, would, by virtue of the superior momentum of the central heavier masses inaugurate a motion which would churn the lighter peripheral fluid into the mountain arches and crevices, in some cases simply producing elevation, in others, giving rise to igneous eruptions upon the crust. If the interior of the earth had the rigidity of steel, a shifting of the centre of gravity would nevertheless lower the peripheral pressure on the far hemisphere, perhaps thus producing liquefaction. This might admit of lava outflows, and, in fact, evidences of such occurrences are not wanting in polar regions. Moreover, such a shifting of the earth's centre of gravity, even if ever so slight, might propagate spherical waves passing outward and imparting terrific impulses to the crust. Such waves would bring into contact different chemical elements separated before by their relative specific gravities, and this would promote intense calorific effects which would react upon the crust. It is possible that the rise of sea level, due to the ice-cap, would depress the sea-bottom and thus elevate the

land by the superadded weight acting tangentially toward the shores. In the opposite hemisphere a new equilibrium would establish itself by the elevation of the sea-bottom and depression of the land. This would, in some degree, neutralize the relative differences of land and water areas to which the shifting of the seas would give rise. It is to be remembered that the intense pressure at the poles during periods of maximum glaciation would precipitate crustal convulsions when the contractile tension due to the radiation of internal heat should have become sufficiently great. These complex factors would all come into play periodically with the periodic recurrence of suitable astronomical conditions.

There is yet another cause of periodicity which has occurred to me. In the deeper parts of the ocean, the hydrostatic pressure must be enormously great. This pressure must force water very deeply into the rocky interstices of the ocean's floor, perhaps so deeply that its permeative power by capillarity is vastly increased (Daubrée 'Géologie Expérimentale,' p. 274). This water coming in contact with the heated rocks of the deeper crust would be vaporized and would also facilitate the evolution of explosive gases. These expansible products would press with tremendous force against their inclosures, and the crust would slowly yield to the irresistible pressure. This crustal movement would continue for a time until the original interstices should have swelled out into fissures sufficiently wide to admit the expansive products to escape as fast as they were formed. A period of quiescence, so far as this force is concerned, would then ensue until the gaps were filled in with sediment when the process would again be renewed. If the erosion of the land during the period of quiet were just sufficient to fill up the gaps we would then have the ideal conditions suggested at the beginning of this article. It should be remembered that the expansive force here considered would have a powerful tangential component which would react landward in each direction tending to produce continental upheavals. Such movements would cause a submergence of the ocean's bed, and this bed would be still farther depressed by the superadded weight of the inrushing waters. Thus there would be an indefinite reciprocal action between the two initial tendencies, each elevation intensifying its correlated depression, and each depression augmenting

the already existing elevation. This reciprocity of effects would, however, be antagonized by at least three counter-tendencies: 1st, the earth's tendency toward sphericity due to the combined action of gravity and its rotational movement. 2d, the rapid re-adjustment by erosion which would ensue from such enormous differences of level. 3d, the disturbed equilibrium of the internal fluid which normally will assume concentric shells with densities inversely proportional to the distance from the centre. All these would oppose the distorting forces here contemplated (and all others producing like effects), and confine the surface movements within rigid limits. Here it should be borne in mind that when the upheaval and consequent expenditure of mechanical energy is great, the energy assuming the form of heat (due to crustal friction) is proportionately diminished, so that the resulting evaporation of oceanic waters, and, hence, the violence of watery precipitations is diminished, but, so far as erosion is concerned this loss is offset by the increased angle of elevation of continents. I am convinced that the heat generated by crustal friction is an important factor in the processes of erosion; for, when developed in emergent land, it will increase the chemical effectiveness of atmospheric moisture coming in contact with it, and thus accelerate disintegration. Where, on the other hand, it is developed in the ocean's bed it will heat the cold polar currents there, part of it being thus conveyed to the equatorial regions there to augment evaporation, and part of it will pass directly by convection to the surface producing a like effect. In the reciprocal elevations and subsidences heretofore alluded to the heat of friction (and consequent evaporation resulting in erosion), would be developed on a prodigious scale. This would promote the rapid leveling mentioned above.

Thus it appears that by an appeal to physical principles we can explain the fact of periodicity in the cycles of sedimentation as a result of several independent forces. While we cannot hope in any given instance to refer a particular upheaval or subsidence to a specific category of causes, yet we may rest assured that one or several of these causes have been operative either isolatedly or conjointly in producing the varied effects. Doubtless minor local disturbances are referable in some cases to purely local causes, although we should not trust too implicitly to such an interpretation. Be

this as it may, there seems to be good reason for referring general and widespread movements occurring during protracted intervals, like those which took place on all the continents during the Carboniferous age to general causes. We have stated before that Dr. Croll refers the movements of this epoch to alternate periods of refrigeration on the northern and southern hemispheres, such periods favoring the formation of an ice cap, and thus, by changing the earth's centre of gravity causing a rise of waters on the refrigerated hemisphere. No doubt this may explain the fact of differences of consecutive strata, but it does not solve the problem of cycles of sedimentation, and it appears to me that a diminishing angle of slope in the wasting land under uniform conditions of precipitation is the only adequate solution. But even this does not explain those grander divisions of geologic time like the Palæozoic, Mesozoic, and Caenozoic. We may suppose that movements like the upheaval at the close of the Lower Silurian, in the Permian, or in Tertiary times were either the expenditures of accumulated tensions created by contractions in the earth's crust, or a contemporaneous action of this with one or more of the other forces enumerated heretofore.

Such a periodicity of major events separated by long intervals of time and interspersed by minor commotions harmonizes with the general hypothesis of a cooling and contracting globe. We would infer that in early times when the crust was thin, the radiation of heat was much more active than now, and general, peripheral convulsions were of frequent occurrence. But owing to the thinness of the crust it could not sustain any very marked elevations without a rupture and outflow of molten matters within. Such outflows, if copious, would obliterate any existing differences of level, and refuse the parts of the crust which were crumpled inward. This process would of necessity continue until the crust should have attained a sufficient thickness to sustain the elevations impressed upon it. Assuming that this was the order of events we would expect that elevations would take place along lines of weakness (see *ante*); that the major contractions would be co simultaneous on different parts of the globe, that the older mountains would have a smaller elevation than those that were formed later, and, finally, inasmuch as the rate of radiation of internal heat sustains an inverse ratio to the thickness of the crust, whereas the resistance to flexure sustains a direct ratio to

that thickness, we would expect that the epochs between successive general disturbances would be progressively longer as the cooling of the interior advanced. On this hypothesis, other things equal, the Palæozoic æon between the Lower Silurian and the Permian would be shorter than the Mesozoic, and this in turn shorter than the Cainozoic. But while these deductions seem well founded, we should be exceedingly cautious about applying them too literally owing to the manifold and intricate aspects of this problem. There seems to be good ground, however, for accepting the general views here set forth. A general synchronism of crustal movements is but a corollary from the doctrine of the identity of geological formations on different parts of the globe. The later formed mountains were undoubtedly colossal compared with earlier ones. We have but to compare the Green mountains (making due allowance for subsequent erosion) which were uplifted at the end of the Lower Silurian (Dana) with the Rockies, Andes, and Himalayas of Tertiary times to realize the greater effectiveness of orogenic forces with the augmented thickness of crust. While we seem forced to admit a general synchronism in the movements of continents as shown in the Eocene period, yet a close parallelism in the cycles of sedimentation should not be expected. Circumstances too numerous and complex to be here considered would modify in endless ways the minuter adjustments and readjustments of land and sea. But this absence of parallelism does not at all invalidate the general doctrine of cycles of sedimentation.

Here it would be interesting to point out the relations subsisting between cycles of sedimentation and geological faunas. *A priori* we feel sure that intimate connections must exist between the two, and the general facts of palæontology seem to sustain the inference. The modifying influences of such cycles must have profoundly affected the development of animal types. But we are too ignorant of the laws of life to speculate upon the *modus operandi* of such developments. We can conjecture this much, however, when the elevation of the land is greatest, the denudation is most energetic, the roily waters will then flow farthest out into the sea, and only mud-loving animals will frequent the neighborhood of the shores. Their remains will be imbedded in the resulting conglomerate. With the diminution of erosive activities new con-

ditions will prevail in adjacent seas, and a different class of organisms will inhabit their waters. When the land has disappeared altogether, the waters will be clear and well suited to the growth of lime-secreting animals. Thus there will be a cycle of living forms corresponding to each cycle of sedimentation, but owing to the long duration of those sedimentary cycles, and the mutability of animal types, the cycles of life will rarely if ever repeat themselves in consecutive cycles of sedimentation.

In conclusion we may say that the general fact of cycles of sedimentation is well established. They are best explained as resulting from the secular elevations and differential rates of erosion of land areas. The elevations must have been periodic. This periodicity was due to other secular phenomena of a more general and fundamental character. The following are the most important of those phenomena: 1st. The secular cooling and consequent contraction of the earth's crust. 2d. The alternate occurrence of periods of refrigeration at the northern and southern hemispheres due to astronomical events. 3d. The generation and expansion of gases and vapors at the bottom of the seas resulting in crustal disturbances. By the independent or united activities of these several forces there have resulted periods of profound and universal disturbances occurring at widely removed intervals of time. While those intervals have been marked by a prevailing quietude, yet there was a continuous succession of minor disturbances related in some complex way to those same general forces, which have given rise to cycles of sedimentation.

July 28, 1891.

EDITORIAL COMMENT.

The study of geology is no light and easy task. Robert Mallet once wrote that to be a geologist a man must first be a chemist, then a physicist, and lastly a mathematician. Geology cannot be mastered by reading the literature of the science, interesting and important as it is. Nor can the alternate loading and discharging of a few pages of a school or college text book make a geologist. Geologus nascitur, non fit, is a true parody of the original. No man can be a geologist unless the stuff is in him.

But possessing this he yet needs careful training. At the same time the subject is so large and the field so wide that scope is afforded for great variety of mental power and habit. The reflective mind can find ample room to usefully indulge his speculative tendency if he only keeps within the limits of reason and judgment. The observing realistic mind will be perfectly at home in a practical portion of the science. Nor are the graces of literary training foreign to the subject, for the power of the geologist to present his favorite theme to others is often and vastly helped by its possession. The stonemason of Edinburgh would never have become the Hugh Miller of geology and literature had he lacked his elegance and power of diction and illustration.

But for success in any field of the science hard and continuous labor and thought are requisite—especially thought. Pondering on the problems before him and working them out in detail, whether in the field or the study, makes the geologist. To realize by the aid of a scientific imagination the past and the lost of the earth's history, to conceive of the destroyed as still in existence, and to estimate and weigh the changes resulting from its destruction, all this involves a power of vivid mental imagery not possessed by many.

Great geologists therefore have been and still are rare. Men who can gather up the work of others and focus it with their own in some grand generalization as Agassiz did for the Ice-age, never will be numerous. But the rank and file of the geological army is not to be despised because each one cannot be the great commander. Every one can contribute to the victory if by patient and careful drill he will fit himself for the work that geology demands.

And this work is the investigation of the problems that lie at his own door. County geology, township geology and even the geology of smaller areas are the topics with which most must content themselves. There is scarcely a county or township between Maine and Oregon, between Minnesota and Mississippi that does not afford enough problems to employ all who desire to work.

"But what shall I study? At what shall I look?" are the usual remarks. Are there fossils within your reach? Then make an effort to secure all the species that occur there and learn to distinguish each one and every single part of each one so as to have a critical acquaintance with them. Are there none? Then

study the river and stream. Why does this stream flow here and that one there? Has the present position been determined by the hardness and softness of the strata or by some other cause? Have the highlands been elevated or are they merely relics of larger masses that have been eroded? To what geological era do the rocks of the county belong, and for what reason are they ascribed to that date?

These are a few samples of the problems lying before the local geologist and his attempts to solve them will give him more geological knowledge than the reading of all the textbooks or the committal of their pages to memory.

I have seen men who knew nothing of book geology, who could not tell whether the Silurian or the Carboniferous strata were the older, and who did not concern themselves with the theoretical questions that divide the geological world, but who were nevertheless, in my opinion, trained and educated men, who could reason closely and severely from their data, and whose queries, suggested by experience, often puzzled learned geologists who heard them. Such men are too scarce.

I do not undervalue study of a wider kind. Let all who can enjoy it. But when it is out of reach let none sit down and say "I cannot study geology."

Such men as described above are often the life and soul of local societies, and it is from their careful and constant work that these societies derive a great part of their value. To both we look for great and increasing results in the future.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

On the Vertebrata from the Tertiary and Cretaceous Rocks of the N. W. Territory.—E. D. COPE. (Geol. Sur. of Canada, Vol. 3 [Quarto], 1891, pp. 25, 14 pls.) In this part (I) Prof. Cope describes "The Species from the Oligocene or Lower Miocene beds of the Cypress Hills." The material, from which these species are described, was found in a bad state of preservation, the bones being much broken, which is accounted for by the fact that the formation from which they were derived is conglomerate of a quartzitic nature. The beds are somewhat older than the White River beds of Dakota, which accounts for the presence of *Hemipsalodon.* Five new species of fishes are described, *Amia whit-*

cavernosa, *A. macrospondyla*, *Rhineastes rheas*, *Amiurus cancellatus*, *A. maconnellii*, the three latter being somewhat doubtful; a new testudinous reptile, *Trionyx leucopotamicus* is also given. A number of mammals are also described, *Menodus* being the principal. It is surprising to note the almost entire absence of the Oreodonts, only one tooth having been found.

The British Tertiary Echinoid Faunas and their Affinities.—J. W. GREGORY, F. G. S. 45 pp. 1 fig. in text. (Proc. Geologists' Association, London, Pts. I and II, 1891.) This is a most important memoir, covering, as it does, the entire Tertiary fauna of the British Isles; the work, however, is deficient in illustrations of the new species described. There is reference to two plates, and it is presumed that they will appear with the next number of the Proceedings. Six new species are described of which four are from the Eocene. According to this author, there are 7 genera and 14 species from the Eocene, 11 genera and 21 species, of which 9 are *Echinus*, from the Pliocene, and five genera and seven species, of which 3 are *Echinus*, from the Pleistocene. The author concludes that the cause of the small number of British echinoids is due entirely to climatic and lithologic conditions; in the Cainozoic, the British seas were cold and free from reefs, both conditions unfavorable to the growth of echinoids. The author also favors the view that a belt of shallow water connected the south of Europe with America during the Cainozoic. A bibliography is appended in which are cited 49 authorities.

The Mesozoic and Tertiary Insects of New South Wales.—R. ETHERIDGE, Jun. and A. S. OLLIFF, 14 pp., 2 heliotype plates. (Memoirs Geol. Sur. New So. Wales, No. 7, 1890.) There are but few Tertiary insects (hardly a dozen) known from the Australian continent, therefore this contribution is particularly timely and important. There are described two new genera (*Mesostigmodera*, belonging to the family *Buprestidæ* and *Palæolycus* belonging to the family *Lampyridæ*, both Coleoptera) and five new species.

On the Osteology of Poëbrotherium.—W. B. SCOTT, Princeton (Jour. Morph. Vol. V, No. 1, June, 1891), pp. 74, 3 pls. and figs. in text. This learned author's "Contribution to the Phylogeny of the Tylopoda" is a beautiful illustration of systematic work. He first gives some interesting examples in evolution and then takes up the *Poëbrotherium*, which he is better able to describe than any other person, not only on account of his well known ability so to do, but also by the fact of the possession of an almost complete skeleton; this skeleton having been discovered by that indefatigable collector, Prof. W. F. Magie, upon the ground which a few months later (in 1890) was made memorable by the Indian outbreak. This skeleton, together with a number of other parts, has enabled Prof. Scott to render this important contribution, and the thorough study of *Poëbrotherium* is indicated by the large number of pages devoted thereto. There is, however, one fault to be found with this paper, viz: the method of giving references, which are numbered,

and refer to the end of the paper, whereas it would seem much better and would afford easier reading, to have the usual foot references. The author says *Protolabis* is the connecting link between *Procamelus* and *Pœbrotherium*, this latter being also the forerunner of the llamas as well as the camels. He thinks the two species of *Procamelus*, *P. occidentalis* and *P. angustidens*, the starting points of the llamas and camels respectively. *Leptotragulus* is the forerunner of the White River *Pœbrotherium*. The Bridger *Homacodon* is connected with *Pantolestes* on theone hand and *Leptotragulus* on the other. "If these conclusions are correct, it follows that the Tylopoda are but remotely connected with the true ruminants." The points in which the modern camels agree with the ruminants and which are absent in the *Pœbrotherium* have been independently acquired. The monograph closes with a bibliography of thirty-four contributions to this and allied subjects. The three plates are magnificent expositions of the art.

The Tudor specimen of Eozoon. J. W. GREGORY, F. G. S. (Quart. Jour. Geol. Soc. Aug. 1891.) After a thorough examination of this specimen of *Eozoon* from Tudor, Hastings Co., Ontario, the author of this paper, supported by many authorities, comes to the already foregone conclusion that it is not of organic origin. It is further stated that the rock containing the specimen is not, as has been previously described, Lower Laurentian but "Huronian" of Selwyn and Vennor.

Stones for Building and Decoration, by GEORGE P. MERRILL, Curator of Geology in the United States National Museum, Octavo, pp. 453. New York. John Wiley & Sons, 1891. All quarrymen and builders who use stone will welcome this volume. It is the first of its kind in America, and it will certainly serve a very useful purpose in the quarrying industry. Quarrymen and stone users are very apt to be ignorant of the mineralogy and geology of the rocks they handle, and the crudest notions concerning them are frequently current. In this volume the composition and other natural qualities of all the building-stones of the country are set out plainly in simple and non-technical, yet in accurate, descriptive, language. This will afford the information that is so badly needed by the ordinary builder, and will disseminate otherwise a more thorough and scientific knowledge of stone. Of course the scientific man does not look into such a work for anything new in science. It is not addressed to such, but it contains many generalizations and summary statements in convenient form which will make it also very useful to him in reference to those portions of the subject with which he may not be personally familiar. It is a compendious dictionary of the production and distribution of stone for construction and decoration in the United States, and also contains chapters on the weathering and preservation of building-stones, and on their comparative qualities. No one has had ampler facilities, and certainly no one could be better fitted for the production of such a work than the curator of geology of the United States National Museum, where samples of all the building-

stones of the country were gathered through the agency of the census of 1880.

Annual Report, Geological Survey of Arkansas, 1888, Vol. IV, J. C. BRANNER, state geologist, Little Rock, 1891, contains: The geology of Washington county, by F. W. SIMONDS, and A list of the plants of Arkansas, by J. C. BRANNER and F. V. COVILLE. The report on Washington county is very full. The county embraces a complete section across the Lower Carboniferous rocks (Chester, St. Louis, Warsaw, Keokuk and Burlington) to which the name "Mississippian" is applied, after the recommendation of the late Dr. A. Winchell. In like manner the Coal Measures of the state, represented only by the basal portion--the Millstone grit—is named Pennsylvanian on the authority of Prof. H. S. Williams.

Meehan's Monthly, published at Germantown, Philadelphia, by Thomas Meehan & Sons, is devoted to general gardening and wild flowers, but it is much more than a gardener's paper, being strictly scientific, and conveying much general botanical information.

LIST OF RECENT PUBLICATIONS.

Foreign Publications.

Surface straining of the earth in relation to the deep phenomena of volcanic action. T. Mellard Reade. (Geol. Mag. Aug. 1890.)

Perched rocks near Austwick. T. Mellard Reade (Geol. Mag. July, 1891.)

On the Killary bay and Slieve Partry Silurian basin, also notes on the metamorphic rocks of northwest Galway. G. Henry Kinahan, (Pro. Roy. Irish Acad. 3rd. Ser., Vol. I, No. 5.)

On the Drifts of Flamborough Head, G. W. Lamplugh, (Quart Jour. Geol. Soc. Aug. 1891).

VI. *Scientific Laboratories and Museums.*

Bulletin of Denison University, Vol. VI, part1, contains; Some observations on the crushing effects of the glacial ice-sheet, W. G. Tight.

CORRESPONDENCE.

New Zealand Glaciers.—The glaciers of Mount Cook (New Zealand) are not a whit behind those of the Alps in some respects. The longest is longer than the longest in the Alps. Then for one ton of superficial moraine matter the Alpine glaciers carry, the Mount Cook glaciers must carry five hundred. The Mueller glacier is a mile in width, and for its lowest three or four miles is completely buried under a load of stones of all sizes, from that of a railway carriage downward. I got about 8,000 feet up Mount Cook, and I think would have attained the summit if I

would have spared another week. It will probably be surmounted in a year or two, as young New Zealanders are getting to get a pride in it, and it will be much easier now, as a "Chalet" has just been completed well up the Hochstetter glacier and will afford a convenient base of operations.

Although there is evidence in old moraines, old high lake levels, and the like, of a former enormous extension of the glaciers, there is, strange to say, hardly any equivalent of the till or boulder clay marking an extensive moraine profonde.

On this subject I may say that when in Adelaide (South Australia), I went with professor Tate to Hallet's cove, in Spencer gulf, to see his glacial markings. Much discredit has been cast on these, but with all the assurance derived from having mapped glacial striæ in Scotland for ten years almost daily, I recognized these as genuine and unmistakable. There was just as little doubt that the ice which made them moved from south to north; let the fact be explained as it may—whether the motive lay in a high land now submerged, or in the heaping up of ice round the south pole. In the latter case the ice should have impinged on other parts of southern Australia and on New Zealand. The marking may not have been recognized because of the prevalence of soft Tertiary rocks unfit to retain impressions, or perhaps because the idea would seem absurd. ROBERT L. JACK.

Townsville, Queensland, Aug. 5, 1891.

MR. CUSHING AND THE MUIR GLACIER.—In the very instructive and interesting paper by Mr. Cushing in the October number of the AMERICAN GEOLOGIST I was specially attracted by his remarks upon p. 221 upon the slight changes of level which seem recently to have taken place at the head of Muir inlet. One indication of the varying phases exhibited by the front of Muir glacier is found in the buried forests described by Mr. Cushing on the east side. During the summer of 1886, when I was there, those buried forests were not visible. Nor did we observe upon the east side any instance of the ice overlapping the sand and gravel, though we saw abundant instances of both phenomena upon the west side. In recurring, however, to a report of Mr. Lamplugh who visited the glacier in 1884, I find that his attention was attracted by the overlapping ice on the east side, and the officers upon the steamer told me of having seen buried stumps at low tide in the same vicinity. Evidently the annual changes going on at the front of the glacier, especially upon the east side, are very rapid and marked, and it would be well if arrangements could be made to have them accurately noted from year to year.

I think Mr. Cushing is probably right in his criticism upon my explanation of the burial of the forests upon the west side of the inlet. My suggestion was that "the dying glacier" had pushed eastward during a period of general advance, so as to obstruct the drainage through Muir Inlet, and certainly the position of the moraine upon this singular glacier looks as though it were an offshoot from the larger ice-stream that at one time filled the west fork of Glacier bay, coming down from mounts Crillon and Fairweather. Mr. Cushing's criticism is also supported by a

fact which I mentioned but did not fully consider in my theory (see Ice Age in North America, p. 61), viz: that there were remnants of a buried forest on the south end of Headland island, which is below the "dying glacier."

A slight modification of my theory, however, would meet this difficulty, namely, that the ice-stream coming down the west fork of the glacier was for a time predominant, and pushed along so far in advance of that which enters the east fork as to obstruct the drainage of Muir inlet, and allow the accumulation of sand and gravel which we now find above the forests.

While there is nothing in the way of supposing a slight subsidence to have occurred sufficient at least to carry down the buried forest on the east side below tide level many facts which have been brought to my observation recently in England make me hesitate about bringing into the theory so large a cause for so small an effect. It has seemed to me that possibly those forests upon the east side, having grown upon an insecure foundation, may have slightly shifted their position, and that, as the inlet has been detpened by the active erosive agencies at work, there may have been a slight slip of extensive portions of the soil upon the east side, so as to carry the buried forests below the sea level. It is possible, also, that this lowering of their level may have been brought about with little or no lateral movement. The occurrence of a bed of quicksand upon which the forest strata rested may have suffered the foundations to be undermined through the action of springs, and thus brought about a local sudsidence sufficient to account for all the facts.

Mr. Cushing's presentation of evidence bearing upon the changeability of the conditions about the eastern sources of Muir Glacier seems fully to justify his criticism of my remark that these forests may have existed before the Glacial period itself. In connection with further study of the region I wish attention might be directed as soon as possible to the glaciers which enter the western fork of the bay, that we might learn whether the changes taking place there are correlated with those upon the Muir glacier.

G. FREDERICK WRIGHT.

Oberlin, Ohio, Oct. 10.

PERSONAL AND SCIENTIFIC NEWS.

THE UNIVERSALITY OF GOLD. Almost every cubic yard of granite, or in fact, of rock of any description, contains from mere traces to often appreciable quantities of metallic gold intermixed amongst the materials forming the rock. Also, it is a scientific fact, and one which has been proven by many actual experiments, that, for every avoirdupois ton of water in the entire bulk of the ocean, there will average about two grains of gold. Or, in other words, there will be found about two grains of gold in the form of a chloride of gold, in every ton of sea water, whether taken from the surface or at the bottom. And, therefore, there are un-

told millions of dollars of gold held in solution by the waters of the ocean, which have been dissolved out of the rocks of the earth by the action of heated alkaline waters containing silica, that have slowly leached and percolated their way throughout the crevices and porous substances of rocks, dissolving out the infinitesimal particles of gold. The primary source of the gold found at the surface of the earth is found to be in the earliest azoic granite; and from these granites it has been altered and formed over and over again through all the succeeding geological horizons to the present period. Or, in other words, the gold of the ancient Archean granites formed during the cooling of the earth's crust, has been dissolved and precipitated and re-dissolved and re-precipitated, over and over, throughout all the rocks of the earth's strata, from the very earliest Azoic to the most recent Quaternary period. Therefore gold may be sought for in every geological horizon; and has thus been found in more or less paying quantities from the very earliest rocks, up to the recent alluvial and drift formations. However, in those veins of quartz which are found in the Cambrian and Lower Silurian strata, gold, in the metallic state, intermixed amongst the quartz, is found in far greater commercial quantity, than in any other of the preceding or subsequent geological horizons. Wherever gold has been found in very large quantity in either vein or placer form, it has been found to be either in a Cambro-Silurian series of slaty rocks and quartz, or else has resulted from the immediate decomposition of those rocks. DR. WILLIS E. EVERETTE.

THE CALUMET AND HECLA MINE is now worked at a depth on the lode of over 4,000 feet with an extent in length of about two and one-half miles. This mine is operated by fourteen shafts, one of which is a six-compartment shaft, now sunk to a perpendicular depth of about 2,500 feet; and which when completed will be upward of 5,000 feet deep. The aggregate power of the steam plant in use and under construction is some 37,500 horse power, including one engine of 4,700 horse power and eleven other engines of an average of 2,000 horse power each. The stamp mills of this mine contain 18 improved Ball steam stamps, making from 95 to 98 blows per minute and crushing about 4,500 tons of rock of the lode in twenty-four hours. The three pumping engines have an aggregate capacity of 50,000,000 gallons in twenty-four hours; while another triple expansion pumping engine, now nearly completed, has alone the capacity of 60,000,000 gallons in twenty-four hours. Besides the two sand wheels forty feet in diameter capable of elevating some 16,000,000 to 18,000,000 gallons of water and 1,600 tons of sand per day, there is nearly completed another wheel fifty-four feet in diameter, designed to elevate 30,000,000 gallons of water and 3,000 tons of sand per day. DR. M. E. WADSWORTH.

APPENDIX.

A CATALOGUE OF THE PALÆONTOLOGICAL PUBLICATIONS OF JOSEPH LEIDY, M. D., LL.D.

By JOHN EYERMAN, Easton, Pa.

Dr. Henry C. Chapman in his "Memoir of Joseph Leidy, M. D., LL.D." (Proc. Acad. Nat. Sci. Phila., 1891, pp. 342-388) gives a list of the recorded publications of this celebrated anatomist, in which there are no less than five hundred and fifty-three communications, principally to the Proceedings of the Academy of Natural Sciences of Philadelphia. It is a noteworthy fact that nearly one-half of these communications relate to vertebrate palæontology. Dr. Chapman's complete bibliography exhibits the wide range of thought, which Dr. Leidy enjoyed in the natural Sciences. At the conclusion of his memoir, Dr. Chapman pays this high tribute to his friend. "Possibly no country ever produced "a student whose knowledge was at once so accurate and comprehensive. "He was an excellent mineralogist and botanist without claiming to be "either, among the highest living authorities on comparative anatomy "and zoology, one of the most distinguished helminthologists living and "the equal of any palæontologist at home or abroad."

1. On the Fossil Horse of America. Proc. Acad.* 3, 1846-47, pp. 262-66.
2. Additional Observations on the Fossil Horse of America. Proc. Acad. 3, 1847, pp. 262-66.
3. On the new Genus and Species of Fossil Ruminantia, Poebrotherium wilsoni, Proc. Acad. 1846-47, pp., 322-26.
3a. Id. Ann. Nat. Hist. I, 1848, pp. 389-92.
3b. Id. Am. J. Sci.† V, 1848, pp. 276-79.
4. On a new Fossil Genus and Species of Ruminantoid Pachydermata, Merycoidodon culbertsonii. Proc. Acad. IV, 1848-49, pp. 47-50.
5. Tapirus americanus fossilis. Proc. Acad. IV, 1848-49, pp. 180-83.
6. On Rhinoceros occidentalis. Proc. Acad. 1850, p. 119.
7. Observations on two new Genera of Mammalian Fossils, Eucrotaphus jacksoni and Archæotherium mortoni. Proc. Acad. V, 1850-51, pp. 90-94.
8. On some Fossil Mammalian Remains. Proc. Acad. V, 1850-51, pp. 121-22.
9. On a Fossil Tortoise, Stylemys nebrascensis. Proc. Acad. V, 1850-51, pp. 124-26.
10. On Fossil Remains of Ruminant ungulates from Nebraska. Proc. Acad. V, 1850-51, pp. 237-39.
11. On the Fossil Remains of Balaena palæatlantica and B. prisca, from the Miocene formation of Virginia. Proc. Acad. V, 1850-51, pp. 308 9.

---

*Proceedings of the Academy of Natural Sciences, Phila.
†American Journal of Science.

12. On some Fossil Reptilian and Mammalian Remains. Proc. Acad. V, 1850-51, pp. 325-30.
13. Description of a new Species of Crocodile from the Miocene of Virginia. Jour. Acad.* II, 1850-54, pp. 135-38.
14. On the Osteology of the Head of Hippopotamus and a Description of the Osteological Characters of a new Genus of Hippopotamidæ. Jour. Acad. II, 1850-54, pp. 207-24.
15. On Bathygnathus borealis, an Extinct Saurian of the New Red Sandstone of Prince Edward Island. Jour. Acad. II, 1850-54, pp. 327-30.
16. On some Fragments of Palæotherium proutii. Proc. Acad. 1851, pp. 170-71.
17. Report upon some Fossil Mammalia and Chelonia from Nebraska. Smith. Rept., 1852, pp. 63-65.
18. Remarks on a Fossil Vertebra from Ouachita, La. Proc. Acad. 1852, p. 52.
19. On the Osteology of Hippopotamus. Proc. Acad. 1852, pp. 52-53.
20. On Fossil Tortoises from Nebraska. Proc. Acad. 1852, p. 59.
21. On two Crania of Extinct Species of Ox. Proc. Acad. 1852, p. 71.
22. Reference to a Fossil Tooth of a Tapir. Proc. Acad. 1852, p. 106.
23. Remarks on the Fossil Ox. Proc. Acad. 1852, p. 117.
24. Remarks on some Fossil Teeth of a Rhinoceros from Nebraska. Proc. Acad. 1852, p. 2.
25. On a Fossil Turtle from Nebraska. Proc. Acad. 1852, p. 34.
26. On a new Species of Fossil Delphinus and a New Saurian, Thoracosaurus grandis. Proc. Acad. VI, 1852-53, p. 35.
27. Ursus amplidens, a new Fossil Species. Proc. Acad. VI, 1852-53, p. 303.
28. On some Fossil Cetacean Remains. Proc. Acad. VI, 1852-53, pp. 377-78.
29. Description of the Remains of Extinct Mammalia and Chelonia from Nebraska Territory, collected during the Geological Survey under the direction of Dr. David Dale Owen. Rept. of Geol. Sur. of Wis., Ia., and Minn., D. D. Owen, 1852, pp. 540-72.
30. Description of an Extinct Species of American Lion, Felis atrox. Am. Phil. Soc. Trans. X, 1853, pp. 319-22.
31. A Memoir on the Extinct Dicotylidæ of America, 1852. Am. Phil. Soc. Trans. X, 1853, pp. 323-44.
32. Memoir on the Extinct Species of American Ox, 1852. Smith. Cont. V, 1853.
33. Remarks on various Fossil Teeth. Proc. Acad. 1853, p. 214.
34. On some Fossil Fragments from Natchez, Miss. Proc. Acad., 1853, p. 303.
35. Remarks on a Collection of Fossil Mammalia and Chelonia from the Mauvaises Terres of Nebraska. Proc. Acad., 1853, pp. 392-94.

*Journal of the Academy of Natural Sciences, Phila.

36. The Ancient Fauna of Nebraska; or a Description of Remains of Extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska, 1852. Smith. Cont. VI, 1854, 392-94.
37. On Brimosaurus grandis, n. g. Proc. Acad. VII, 1854, p. 72.
38. On Bison latifrons. Proc. Acad. VII, 1854, p. 89.
39. On Dinictis felina. Proc. Acad. 1854, p. 127.
40. Hippodon and Merycodus, new fossil genera indicated. Proc. Acad. VII, 1854-55, p. 90.
41. Synopsis of Extinct Mammalia, the Remains of which, have been discovered in the Eocene formations of Nebraska. Proc. Acad. VII, 1854-55, pp. 156-58.
42. Description of a Fossil apparently indicating an Extinct Species of the Camel tribe. Proc. Acad. VII, 1854-55, pp. 172-73.
43. Notice of some Fossil Bones, discovered by Mr. Francis A. Lincke, in the banks of the Ohio river, Indiana. Proc. Acad. VII, 1854-55, pp. 199-201.
44. Remarks on the question of the Identity of Bootherium cavifrons with Ovibos moschatus or O. maximus. Proc. Acad. VII, 1854-55, pp. 209-10.
45. Indications of twelve Species of Fossil Fishes from New Jersey and S. Carolina. Proc. Acad. VII, 1854-55, pp. 395-97.
46. Indications of five Species, with two new Genera, of Extinct Fishes. Proc. Acad. VII, 1854-55, p. 414.
47. A Memoir on the Extinct Sloth Tribe of North America, 1853 Smith. Cont. VII, 1855.
48. On a so-called Fossil Man. Proc. Acad. 1855, p. 340.
49. Description of some Remains of Fishes from the Carboniferous and Devonian Formations of the United States. Jour. Acad. III, 1855-58, pp. 159-62.
50. Descriptions of some Remains of Extinct Mammalia. Jour. Acad III, 1855-58, pp. 166-71.
51. Descriptions of Two Ichthyodurulites. Proc. Acad. VIII, 1856, pp. 11-12.
52. Notices of some Remains of Extinct Mammalia, discovered by Dr. F. V. Hayden in the Bad Lands of Nebraska. Proc. Acad. VIII, 1856, pp. 59-60.
53. Notices of Remains of Extinct Reptiles and Fishes, discovered by Dr. F. V. Hayden, in the Bad Lands of Judith river, Nebraska Territory. Proc. Acad. VIII, 1856, pp. 72-75.

53a. *Id.* Am. J. Sci. XXI, 1856, pp. 422-23.

54. Notices of Remains of Extinct Mammalia, discovered by Dr. F. V. Hayden in Nebraska Territory. Proc. Acad. VIII, 1856, pp. 88-90.
55. Notices of the Remains of a Species of Seal, from the Post-Pliocene Deposit of the Ottawa river. Proc. Acad. VIII, 1856, pp. 90-91.
56. Notices of several Genera of Extinct Mammalia, previously less perfectly characterized. Proc. Acad. VIII, 1856, pp. 91-92.

57. Notices of some Remains of Extinct Vertebrated Animals. Proc. Acad. VIII, 1856, pp. 162-65.
58. Notices of some Remains of Extinct Vertebrated Animals collected by Prof. Cook. Proc. Acad. VIII, 1856, pp. 220-21.
59. Notices of some Remains of Extinct Vertebrated Animals, discovered by Prof. E. Emmons. Proc. Acad. VIII, 1856, pp. 255-56.
59a. *Id.* Am. J. Sci. XXIII, 1857, pp. 271-72.
60. Notices of some Remains of Fishes, discovered by Dr. John E. Evans. Proc. Acad. VIII, 1856, pp. 256-57.
61. Notices of Remains of Two Species of Seals. Proc. Acad. VIII, 1856, 265.
62. Remarks on certain Extinct Species of Fishes. Proc. Acad. VIII, 1856, pp. 301-2.
63. Notices of Remains of Extinct Turtles of New Jersey, collected by Prof. Cook. Proc. Acad. VIII, 1856, pp. 303-4.
64. Notices of Extinct Vertebrata, discovered by Dr. F. V. Hayden, during the expedition to the Sioux country. Proc. Acad. VIII, 1856, pp. 311-12.
65. List of Extinct Vertebrata, the remains of which have been discovered in the region of the Missouri river; with remarks on their geological age. Proc. Acad. IX, 1857, pp. 89-91.
66. Notices of some Remains of Extinct Fishes, Proc. Acad. IX, 1857, pp. 167-68.
67. On New Red Sandstone Fossils from the Gwynnedd Tunnel N. P. R. R. Proc. Acad., 1857, p. 150.
68. Rectification of the References of the Extinct Mammalian Genera of Nebraska. Proc. Acad. 1857, pp. 175-76.
69. On the Dentition of Mososaurus. Proc. Acad. 1857, p. 176.
70. Notices of Remains of Extinct Vertebrata, from the Valley of the Niobrara river, collected during the exploring expedition of 1857, by Dr. F. V. Hayden. Proc. Acad. X, 1858, pp. 20-29.
71. Remarks on Fossil Mammalia from Nebraska. Proc. Acad. 1858, p. 7.
72. Notice of Remains of Extinct Vertebrata from the Valley of the Niobrara river. Proc. Acad. 1858, p. 11.
73. Remarks on a Cast of a Mastodon Tooth. Proc. Acad. 1858, p. 12.
74. Remarks on Fossil Remains from Nebraska. Proc. Acad. 1858, pp. 89-90.
75. Remarks on Hadrosaurus foulkii. Proc. Acad. 1858, pp. 215-18.
76. On Hystracanthus arcuatus and Cladodus occidentalis. Proc. Acad. 1859, p. 3.
77. Remarks on Tooth of Mastodon and Bones of Mosasaurus. Proc. Acad. 1859, pp. 91-92.
78. Remarks on Teeth of Clepsysaurus, Eurydorus serridens and Compsosaurus from Phœnixville Tunnel, Chester Co., Pa. Proc. Acad. 1859, p. 110.
79. Remarks on Fossils from Bethany, Va., and also from the Greensand of Monmouth Co., N. J. Proc. Acad. 1859, p. 110.

80. Remarks on Ossite from Sombrero, W. I., and on skull of Ursus americanus from the drift of Claiborne, Ala. Proc. Acad. 1859, p. 111.
81. Remarks on Fragment of Jaw of Mosasaurus. Proc. Acad. 1859, p. 150.
82. On Specimens of Palæotrochus from sub-Silurian Strata. Proc. Acad. 1859, p. 150.
83. Remarks on Dromatherium sylvestre and other Fossils from Chatham Co., N. C. Proc. Acad, 1859. p. 162.
84. Remarks on the Antler of the Reindeer found at Sing Sing and Remarks on Freija americana from Newport. Proc. Acad. 1859, p. 194.
85. Description of the Remains of Fishes from the Carboniferous limestone of Illinois and Missouri, 1856. Trans. Amer. Phil. Soc. XI, 1860, pp. 83-87.
86. Remarks on Saurocephalus and its allies, 1856. Trans. Amer. Phil. Soc. XI, 1860, pp. 91-95.
87. Observations on the Extinct Peccary of North America; being a sequel to "A Memoir on the Extinct Dicotylinae of America," 1856. Trans. Am. Phil. Soc. XI, 1860, pp. 97-105.
88. Remarks on the Structure of the Feet of Megalonyx, 1856. Trans Am. Phil. Soc. XI, 1860, pp. 107-108.
89. Extinct Vertebrata from the Judith River and Great Lignite Formations of Nebraska. Trans. Am. Phil. Soc. XI, 1860, pp. 139-154.
90. Remarks on Fossil Teeth of Hippotherium from Washington Co., Texas. Proc. Acad., 1860, p. 416.
91. Remarks on an Extinct Peccary from Dr. D. D. Owen. Proc. Acad. 1860, 416.
92. Cretaceous Reptiles of the United States, 1864. Smith. Rept. 1864, pp. 66-73.
92a. *Id.* Smith. Cont. XIV, 1865 (Art. 6).
92b. *Id.* Geological Magazine, V, 1868, pp. 432-35.
93. Fossil Remains of Horses from California. Proc. Acad. 1865, p. 94.
94. Fossil Remains of Rhinoceros from Texas and California. Proc. Acad. 1865, pp. 176-77.
95. On Bones and Stone Implements from Guano deposits in the Island of Orchilla. Proc. Acad. 1865, pp. 181-83.
96. Remarks on a Phalynx of an Extinct Reptile. Proc. Acad. 1866, p. 9.
97. Remarks on Human Relics at Petite Anse, La. Proc. Acad. 1866, p. 109.
98. Remarks on Fossils presented June 5. Proc. Acad. 1866, p. 237.
99. On Fossil Bones from Mauvaises Terres, Nebraska. Proc. Acad. 1866, p. 345.
100. Remarks on the Skull of Bison latifrons. Proc. Acad. 1867, p. 85.
101. Exhibition of the skull of Geomys bursarius. Proc. Acad. 1867, p. 97.

102. On the skull of Castoroides ohioensis. Proc. Acad. 1867, p. 97.
103. Notices of some Vertebrate Remains from Hardin Co., Texas. Proc. Acad. 1868, pp. 175-76.
104. Indication of an Elotherium in California. Proc. Acad. 1868, p. 177.
105. Notices of some Reptilian Remains from Nevada. Proc. Acad. 1868, 178-80.
106. Notices of some Vertebrate Remains from the West Indian Islands. Proc. Acad. 1868, pp. 178-80.
107. Notices of some Remains of Horses. Proc. Acad. 1868, p. 195.
108. Notices of some Extinct Cetaceans. Proc. Acad 1868, pp. 197-99.
109. Remarks on a Jaw Fragment of Megalosaurus. Proc. Acad. 1868, pp. 197-99.
110. Notices of American Species of Ptychodus. Proc. Acad. 1868, pp. 205-6.
111. Notices of some Remains of Extinct Pachyderms: Dicotyles nasutus, Anchippus texanus, Anchippodus riparius, Lophiodon occidentalis. Proc. Acad. 1868, pp. 315-16.
112. Notices of some Remains of Extinct Insectivora from Dakota. Proc. Acad. 1868, pp. 315-16.
113. On Photograph of Fossil Bones from Topeka, Kas. Proc. Acad. 1868, p. 315.
114. On the Extinct Mammalia from Dakota and Nebraska, including an account of some allied forms from other localities. Jour. Acad. VII, 1869, pp. 23-362.
115. Synopsis of Extinct Mammalia of North America. Jour. Acad. VII, 1869 pp. 363-472.
116. Notices of some Extinct Vertebrates from Wyoming and Dakota. Proc. Acad. 1869, pp. 63-67.
117. Elasmosaurus platyurus, Cope. Am. J. Sci. XLIX, 1870, p. 392.
118. Fossil Sivatherium from Colorado Megacerops coloradensis. Proc. Acad. 1870, pp. 1-13.
119. Remarks on Poicilopleuron valens, Baptemys wyomingensis, Emys stevensonianus and other Fossils from the Middle Park, Colorado. Proc. Acad. 1870, pp. 3-5.
120. On Reptilian Remains from the Cretaceous formation near Fort Wallace, Kansas. Proc. Acad. 1870, pp. 9-10.
121. On a Fossil Mandible from near Fort Bridger, Wyoming. Proc. Acad. 1870, pp. 10-11.
122. Remarks on Xiphactinus audax and other Ichthyodorulites. Proc. Acad. 1870, pp. 12-13.
123. Remarks on Asteracanthus siderius. Proc. Acad. 1870, p. 13.
124. On Hadrosaurus and its allies. Proc. Acad. 1870, pp. 67-68.
125. Descriptions of Oncobatis pentagonus and Mylocyprinus robustus. Proc. Acad. 1870, pp. 69-71.
126. On Mastodon Remains of the Warren Museum and the Cambridge University Museum. Proc. Acad. 1870, pp. 96-99.
127. On Crocodilus elliotti. Proc. Acad. 1870, pp. 100, 122.

128. On some Fossils from the Sweet Water river, Wyoming Territory. Proc. Acad. 1870, pp. 109-110.
129. Description of a new Species of Oreodon: O. superbus. Proc. Acad. 1870, pp. 111-112.
130. On Anchitherium condoni and Cordylophora americana. Proc. Acad. 1870, pp. 113-113.
131. Descriptions of Palæosyops paludosus, Microsus cuspidatus and Notharctus tenebrosus. Proc. Acad. 1870, pp. 113-114.
132. Descriptions of Graphiodon vinerius, a fossil reptile. Proc. Acad. 1870, p. 122.
133. Reptilian Remains from Wyoming; Emys jeanesi, E. haydeni, Bæna arenosa. Proc. Acad. 1870, pp. 123-24.
134. Fossil Remains of a Lacertian, discovered near Granger: Saniwa ensidens Proc. Acad. 1870, pp. 124-25.
135. Fossil Fragment of the Lower Jaw of a small Pachyderm; Lophiotherium sylvaticum. Proc. Acad. 1870, p. 126.
136. On the Humerus of a Sloth resembling Mylodon robustus and on Dromotherium sylvestre. Proc. Acad. 1870, pp. 8-9.
137. On Specimens of Vertebral Bodies from the New Jersey Green-Sand. Proc. Acad. 1870, p. 10.
138. On Ichthyodorulites. Proc. Acad. 1870, pp. 12-13.
139. On Fossil Remains from Illinois. Proc. Acad. 1870, p. 13.
140. On Discosaurus and its allies. Proc. Acad, 1870. pp. 18-22.
141. On Fossil Bones from Dakota and Nebraska. Proc. Acad. 1870, pp. 65-66.
142. On Fossil Remains from Idaho, Utah and Oregon. Proc. Acad. 1870, pp. 67-8.
143. On Fossils from the vicinity of Burlington, Kas., and from the Rocky Mts. Proc. Acad. 1870, p. 69.
144. On the Relations of European and American fauna. Proc. Acad. 1870, pp. 72-73.
145. On a Jaw Fragment of Ovibos cavifrons. Proc. Acad. 1870, p. 73.
146. Nothosaurops occiduus. Proc. Acad. 1870, p. 74.
147. On Mastodon Remains. Proc. Acad. 1870, pp. 96-99.
148. On Fossil Remains in the Museum of Amherst College. Proc. Acad. 1870, p. 98.
149. On Fossils from Bridge creek, Oregon. Proc. Acad. 1870, pp. 111-113.
150. On Cordylophora. Proc. Acad. 1870, p. 113.
151. On Fossils from Church Buttes, Wyoming Territory. Proc. Acad. 1870, pp. 113-114.
152. On Fossils found under Table Mt. Cal. Proc. Acad. 1870, pp. 125-26.
153. On some Extinct Turtles from Wyoming Territory. Proc Acad. 1870, pp. 102-103.
154. Remains of Extinct Mammals from Wyoming. Proc. Acad. 1871, pp. 113-14.
155. Remains of Palæosyops from Fort Bridger. Proc. Acad. 1871, p. 118.

156. Remarks on a Fossil Testudo from Wyoming. Proc. Acad. 1871, p. 154.
157. Remarks on Supposed Fossil Turtle Eggs. Proc. Acad. 1871, pp. 154-55.
158. Fossils from Wyoming. Proc. Acad. 1871, p. 197.
159. Remarks on Fossil Vertebrates from Wyoming. Proc. Acad. 1871, pp. 228-29.
160. Notice of some Extinct Rodents from Wyoming, and description of Mysops minimus. Proc. Acad. 1871, pp. 230-32.
161. Remarks on Fossils from Oregon; Hadrohyus supremus, Rhinoceros pacificus Stylemys oregonensis. Proc. Acad. 1871, pp. 247-48.
162. On a small Collection of Fossils from California. Proc. Acad. 1871, p. 50.
163. On Polydactylism in a Horse. Proc. Acad. 1871, p. 112.
164. On Remains of Mastodon and Horse in North Carolina. Proc. Acad. 1871, p. 113.
165. Remarks on Mastodon, etc., from California. Proc. Acad. 1871, pp. 198-99.
166. Note on Anchitherium. Proc. Acad. 1871, p. 199.
167. Remarks on Fossil Vertebrates from Wyoming. Proc. Acad. 1871, pp. 228-9.
168. On some new Species of Fossil Mammalia from Wyoming: Palæosyops humilis Uintatherium robustum, Uintamastix atrox. Am. J. Sci. IV, 1872, pp. 239-40.
168a. *Id.* Proc. Acad. 1872, pp. 167-69.
169. Remarks on Fossils from Wyoming. Proc. Acad. 1872, pp. 19-21.
170. Remarks on some Extinct Mammals. Proc. Acad. 1872, pp. 37-38.
171. Remarks on some Extinct Vertebrates: Felis augustus, Oligosimus grandævus, Tylosteus ornatus. Proc. Acad. 1872, pp. 38-40.
172. On a new genus of Extinct Turtles. Proc. Acad. 1872, p. 162.
173. On some Remains of Cretaceous Fishes: Otodus divaricatus, Oxyrhina extenta, Acrodus humilis, Pycnodus faba. Proc. Acad. 1872, pp. 162-64.
174. Remarks on Fossil Mammals from Wyoming; Uintatherium robustum, Palæosyops major. Proc. Acad. 1872, pp. 240-42.
175. Remarks on chipped stones from Wyoming. Proc. Acad. 1872, pp. 242-43.
176. Remarks on Fossils from Wyoming; Palæosyops junior, Uintacyon edax, U. vorax, Chameleo pristinus. Proc. Acad. 1872, p. 277.
177. Remarks on Mastodon from New Mexico. Proc. Acad. 1872, p. 142.
178. Remarks on Fossil Shark Teeth. Proc. Acad. 1872, p. 166.
179. Contributions to the Extinct Fauna of the Western Territories. Rept. U. S. Geol. Sur. of Ter. (Hayden), I, 1873, pp. 1-358, pls. I-XXXVII.
180. Notice of Fossil Vertebrates from the Miocene of Virginia. Proc. Acad. 1873, p. 15.
181. Notice of Remains of Fishes in the Bridger Tertiary formation of Wyoming. Proc. Acad. 1873, pp. 97-99.

182. Remarks on the Occurrence of an Extinct Hog in America. Proc. Acad. 1873, p. 207.
183. Remarks on Extinct Mammals in California. Proc. Acad. 1873, pp. 259-60.
184. Remarks on Fossil Elephant Teeth. Proc. Acad. 1873, pp, 416-17.
185. Notice of Remains of Titanotherium. Proc. Acad. 1874, pp. 165-66.
186. Remarks on Fossils presented. Proc. Acad. 1874, pp. 223-24.
187. Description of Vertebrate Remains chiefly from the Phosphate Beds of South Carolina. Jour. Acad. VIII, 1874-81, pp. 209-61.
188. Remarks on Bathygnathus borealis. Jour. Acad. VIII, 1874-81, pp. 449-51.
189. Remarks on a Coal Fossil, etc. Proc. Acad. 1875, p. 120.
190. Remarks on Elephant Remains. Proc. Acad. 1875, p. 121.
191. On Petalodus. Proc. Acad. 1876, p. 9.
192. Mastodon andium. Proc. Acad. 1876, p. 38.
193. Remarks on Fossils from the Ashley Phosphate Beds. Proc. Acad. 1876, pp. 80-81, 86-87.
194. Fish Remains of the Mesozoic Red Shales. Proc. Acad. 1876, p. 81.
195. Remarks on Fossils from the Ashley Phosphate Beds. Proc. Acad. 1876, pp. 86-87.
196. Remarks on the Vertebrate fossils from the Phosphate Beds of S. Carolina. Proc. Acad. 1876, pp. 114-15.
197. On Fossil Fishes. Proc. Acad. 1877, p. 294.
198. Fossil Remains of a Caribou. Proc. Acad. 1879, pp. 32-33.
199. Fossil Foot Tracks of the Anthracite Coal Measures. Proc. Acad. 1879, pp. 164-65.
200. Bone Caves of Pennsylvania. Proc. Acad. 1880, pp. 346-49.
201. On Remains of Horses. Proc. Acad. 1882, pp. 290-92.
202. On an Extinct Peccary. Proc. Acad. 1882, pp. 301-302.
203. Fossil Bones from Louisiana. Proc. Acad. 1884, p. 22.
204. Vertebrate Fossils from Florida. Proc. Acad. 1884, pp. 118-119.
205. Rhinoceros and Hippotherium from Florida. Proc. Acad. 1885, pp. 32-33.
206. Remarks on Mylodon. Proc. Acad. 1885, pp. 49-51.
207. Mastodon and Llama from Florida. Proc. Acad. 1886, pp. 11-12.
208. Extinct Boar from Florida. Proc. Acad. 1886, pp. 37-38.
209. Caries in the Mastodon. Proc. Acad. 1886, p. 38
210. Toxodon and other Remains from Nicaragua. Proc. Acad. 1886, 275-77.
211. Fossil Bones from Florida. Proc. Acad. 1887, pp. 309-10.
212. Megalonyx jeffersonii. Proc. Acad. 1888, p. 273.
213. The Sabre-tooth Tiger of Florida. Proc. Acad. 1889, pp. 29-31.
214. Fossil Vertebrates from Florida. Proc. Acad. 1889, pp. 96-97.
215. Notice of some Fossil Human Bones. Trans. Wagner Free. Inst. Sci. II, pp. 9-12*.

*Transactions of the Wagner Free Institute of Science, Philadelphia.

216. Description of Mammalian Remains from a rock crevice in Florida. Trans. Wag. Fr. Ins. Sci. II, 1889, pp. 13-17.
217. Description of Vertebrate Remains from Peace Creek, Florida. Trans. Wag. Fr. Ins. Sci. II, 1889, pp. 19 31.
218. Notice of some Mammalian Remains from the Salt Mine of Petite Anse, Louisiana. Trans. Wag. Fr. Ins. Sci. II, 1889, pp. 33-40.
219. On Platygonus, an extinct genus allied to the Peccaries. Trans. Wag. Fr. Ins. Sci. II, 1889, pp. 41-50.
220. Fossil Vertebrates from Florida. Proc. Acad. 1890, pp. 64-65.
221. Hippotherium and Rhinoceros from Florida. Proc. Acad. 1890, pp. 182-83.
222. Mastodon and Capybara of South Carolina. Proc. Acad. 1890, pp. 184-85.

scientists in this country through the courteous kindliness of his demeanor, no less than through the earnestness of his zeal. Although but about eleven years of his life were spent in the United States, coming to this country wholly unknown and without recommendations or introduction, he entered upon a career which soon conducted him into the favorable consideration of the highest authorities of the Government at Washington, and when he died he was in the service of the Bureau of Topographical Engineers.

Born in France, whence also came Guyot, and Agassiz and Lesquereux, a brilliant group whose illumination the nineteenth century will always bear, he also brought to America and consecrated to her service a ripe education and great skill in manipulation of scientific methods. He was born in 1790 at Cluses, in Savoy, between Geneva and Mont Blanc, and died Sept. 18, 1843, probably at the house of Prof. Ducatel, in Baltimore, Md. In boyhood he was obliged, through the poverty of his parents, to earn some portion of his livelihood. The musical ability which he displayed in later life, by which he enlivened the households of general Sibley and of Indian agent Taliaferro, at Fort Snelling, seems to have marked out for him the most successful means of gaining such subsistence. With a flute or a violin, at the tender age of ten years, he played at such public or private entertainments as needed his services. He subsequently was apprenticed to a watch-maker, and remained with him until he was eighteen years of age. While carrying on this occupation at Chambry he prosecuted his studies in mathematics, in which he became so proficient that he was awarded a prize. Returning to Cluses he taught mathematics, and at the same time received lessons in Latin and other languages. After two years he repaired to Paris where he was admitted to the first class in L'Ecole Normale; and soon afterwards he was placed in charge of the mathematical course in the college of "Louis le Grand."

"It was in 1818 that Nicollet published his celebrated letter to M. Outrequin Banquier, on 'Assurances having for their basis the probable duration of human life.' This little work gained for him a high reputation, affording to the Assurance Societies the prospect of establishing their regulations upon the more certain basis of mathematical demonstration, and he soon found himself courted by financiers, while at the same time he was ad-

mitted into the higher circles of society. Shortly after he wrote for the 'Modern Encyclopedia' several articles on *probabilities*, and one upon *assurances*. It is stated that his knowledge of the English gave him a great advantage, in being able to consult writers in that language on the theory of assurances in applying it to every species of risks."

In 1819 and 1820 he made observations upon the lunar spot Manilus, and united them with those of Bouvard in 1806, with a discussion of the whole, published in 1822 and 1823 in *Connaissances des Temps*. On the 21st of January, 1821, he discovered, between six and seven in the evening, a comet in the constellation Pegasus, seen on the same day and the same hour by Pons, of Marseilles. He subsequently computed its parabolic elements. In a later discovery of another comet (April 22, 1830) he was preceded by M. Gambart, of Marseilles, who saw it on the 21st of the same month. We are also indebted to Nicollet for observations and computations of other comets, among which may be mentioned that of 1823, whose elements he computed. He had already labored some time in the Observatory at Paris, when in 1822, he entered the "Bureau des Longitudes" as an adjunct. His position for the future was thus most honorably established. The publications of the Observatory will show the part he took in the observations. He participated in that great work, the determination of the figure of the earth, by comparing a measured terrestrial arc with the celestial arc corresponding to it. These labors were published in "Connaissances des Temps" for 1829. A memoir of his on a new computation of the latitudes of certain places, to serve as a supplement to that great work, the "Base du Systeme metrique," was published in 1828.

Nicollet was honored by the decoration of the Legion of Honor, previous to 1825, and had also the appointment of professor to the Royal College of Louis Le Grand. Having also been appointed one of the Inspectors of the Naval Schools, conjointly with MM. Reynaud and Gerand he published a course in mathematics in three volumes, for the use of candidates for promotion, the second volume, containing geometry and trigonometry, being edited solely by himself.

In 1831 he determined the comparative magnetic intensity of Brest, with reference to that of Paris and Brussels, and the results were inserted in the first volume of the Bulletins. Several

of his communications were inserted in the publications of the Royal Academy of Science and Belles Lettres of Brussels, of which he was made a corresponding member.

In conjunction with this course of scientific promotion Nicollet's financial success had kept equal pace, and he had accumulated a considerable sum of money. New avenues of profit opened before him, and tempted by his uniform success, he launched boldly forth upon a sea of speculation, with firm confidence in his theory of probabilities. He failed, and with the disappearance of his own fortune the fortunes of others were involved. He was forced to seek refuge in the United States, his former friends being found among his most bitter and implacable persecutors.

He arrived in this country in 1832, apparently having landed at New Orleans. He was an entire stranger and with limited pecuniary means. In the progress of a systematic journey through the states of the lower Mississippi valley, he made the acquaintance of bishop Chanche, of Natchez, and a friendship sprang up between them which continued till Nicollet's death. Through the agency of P. Chouteau, Jr., & Co., of St. Louis, extensive Indian traders in the Northwest, by whom Nicollet was entertained on the most cordial terms, and of major Taliaferro, Indian agent at Fort Snelling, the desire which Nicollet had expressed of exploring thoroughly the upper waters of the Mississippi, and accurately mapping the same, was made known to the United States Government. In 1833 the War Department furnished him letters of protection and hospitality, addressed to the commanding officers and Indian agents of the frontier, and at the same time the loan of certain instruments needed by him. Aside from these inconsiderable aids, however, Nicollet entered upon a great undertaking alone, and at his own expense and risk. He was everywhere received with great cordiality. He had been schooled to the social observances which make daily intercourse attractive. His mind was of the higher order. His mathematical and musical abilities, his delicate physical frame, his unostentatious demeanor, his readiness to enter into social converse, and to impart information on topics which are the less understood and but seldom discussed in the unsettled communities in which he now found himself, and his general scientific attainments, conspired to furnish him a passport into the best circles.

The late general H. H. Sibley, and Indian agent Taliaferro, testify to the pleasure with which they received and entertained Nicollet during the winter months, at Mendota and Fort Snelling, when his active explorations were suspended, and he was engaged in constructing his preliminary map. "In those days when the nearest settlement of whites was nearly three hundred miles distant, the advent of a decent and intelligent visitor was hailed with delight."

Until 1838 Nicollet was thereafter engaged in mapping the region of the upper Mississippi. He was accompanied by experienced Canadian frontiersmen, selected usually by the fur companies, (Chouteau & Co., of St. Louis,) and frequently from their own men. He employed for the first time in this region those methods and principles which have been the basis of all the more recent surveys. The vastness of the area which he covered alone rendered it necessary to depend on more inaccurate methods for filling in the details between the points astronomically determined. Wherever Mr. Nicollet went, he was indefatigable in the use of the telescope for observing occultations and eclipses, and of the sextant, with which he was very skillful. With these, a pocket chronometer, artificial horizon of mercury and barometer, he obtained astronomic and topographic results, possessing remarkable accuracy for the means employed. Mr. Nicollet was the first explorer who made use of the barometer in obtaining the elevation of our great interior country above the sea. An abstract of the methods and principles by which he was governed is given in his report, and these have served as a guide to many subsequent observers.

The preliminary map which he thus constructed extended on the east from the longitude of Madison in Wisconsin to the one hundredth meridian, and from the northern international boundary to the parallel of 38 degrees and 30 minutes, which is just below the mouth of the Missouri river. It embraced not alone the accurate location of rivers and lakes, and the representation of the principal topographic elevations, but it showed many details of historic discovery and geography, and facts respecting the location of the Indian tribes, and the aboriginal names for streams and lakes. Nicollet familiarized himself with early discovery, and particularly with the early French explorations, and it was one of his aims to resuscitate and reclaim for his countrymen the

of his communications were inserted in the publications of the Royal Academy of Science and Belles Lettres of Brussels, of which he was made a corresponding member.

In conjunction with this course of scientific promotion Nicollet's financial success had kept equal pace, and he had accumulated a considerable sum of money. New avenues of profit opened before him, and tempted by his uniform success, he launched boldly forth upon a sea of speculation, with firm confidence in his theory of probabilities. He failed, and with the disappearance of his own fortune the fortunes of others were involved. He was forced to seek refuge in the United States, his former friends being found among his most bitter and implacable persecutors.

He arrived in this country in 1832, apparently having landed at New Orleans. He was an entire stranger and with limited pecuniary means. In the progress of a systematic journey through the states of the lower Mississippi valley, he made the acquaintance of bishop Chanche, of Natchez, and a friendship sprang up between them which continued till Nicollet's death. Through the agency of P. Chouteau, Jr., & Co., of St. Louis, extensive Indian traders in the Northwest, by whom Nicollet was entertained on the most cordial terms, and of major Taliaferro, Indian agent at Fort Snelling, the desire which Nicollet had expressed of exploring thoroughly the upper waters of the Mississippi, and accurately mapping the same, was made known to the United States Government. In 1833 the War Department furnished him letters of protection and hospitality, addressed to the commanding officers and Indian agents of the frontier, and at the same time the loan of certain instruments needed by him. Aside from these inconsiderable aids, however, Nicollet entered upon a great undertaking alone, and at his own expense and risk. He was everywhere received with great cordiality. He had been schooled to the social observances which make daily intercourse attractive. His mind was of the higher order. His mathematical and musical abilities, his delicate physical frame, his unostentatious demeanor, his readiness to enter into social converse, and to impart information on topics which are the less understood and but seldom discussed in the unsettled communities in which he now found himself, and his general scientific attainments, conspired to furnish him a passport into the best circles.

The late general H. H. Sibley, and Indian agent Taliaferro, testify to the pleasure with which they received and entertained Nicollet during the winter months, at Mendota and Fort Snelling, when his active explorations were suspended, and he was engaged in constructing his preliminary map. "In those days when the nearest settlement of whites was nearly three hundred miles distant, the advent of a decent and intelligent visitor was hailed with delight."

Until 1838 Nicollet was thereafter engaged in mapping the region of the upper Mississippi. He was accompanied by experienced Canadian frontiersmen, selected usually by the fur companies, (Chouteau & Co., of St. Louis,) and frequently from their own men. He employed for the first time in this region those methods and principles which have been the basis of all the more recent surveys. The vastness of the area which he covered alone rendered it necessary to depend on more inaccurate methods for filling in the details between the points astronomically determined. Wherever Mr. Nicollet went, he was indefatigable in the use of the telescope for observing occultations and eclipses, and of the sextant, with which he was very skillful. With these, a pocket chronometer, artificial horizon of mercury and barometer, he obtained astronomic and topographic results, possessing remarkable accuracy for the means employed. Mr. Nicollet was the first explorer who made use of the barometer in obtaining the elevation of our great interior country above the sea. An abstract of the methods and principles by which he was governed is given in his report, and these have served as a guide to many subsequent observers.

The preliminary map which he thus constructed extended on the east from the longitude of Madison in Wisconsin to the one hundredth meridian, and from the northern international boundary to the parallel of 38 degrees and 30 minutes, which is just below the mouth of the Missouri river. It embraced not alone the accurate location of rivers and lakes, and the representation of the principal topographic elevations, but it showed many details of historic discovery and geography, and facts respecting the location of the Indian tribes, and the aboriginal names for streams and lakes. Nicollet familiarized himself with early discovery, and particularly with the early French explorations, and it was one of his aims to resuscitate and reclaim for his countrymen the

credit for what they had done, for at that time it had lapsed from common acknowledgement. This was freely communicated to bishop Chanche and to Chouteau & Co., as well as others, and it doubtless served to enlist all French citizens heartily in his aid. Col. Abert, chief of the engineer corps of the U. S. army, had kept himself acquainted with the progress of Nicollet's surveys, although there is no evidence of any official communications between them. Hon. J. R. Poinsett, of S. Carolina, at the head of the War Department, was also informed of his self-instituted and self-sacrificing labors. At this time there was a general popular demand, for political reasons touching the controversy with Great Britian concerning the Oregon boundary, for knowledge of the nature of the country westward from the upper waters of the Mississippi,, and when Nicollet, in 1838, with broken health and exhausted means, repaired to Baltimore, where he again enjoyed the friendly hospitality of bishop Chanche, at St. Mary's College, and of Prof. Ducatel, he was soon officially called to Washington by Mr. Poinsett for the inspection of his maps and journals. Mr. Poinsett and Col. Abert were gentlemen of kindred spirits, and they appreciated and esteemed the character of Nicollet. They also saw at once the importance to the country of securing for the government the materials collected by Nicollet in his excursions. The result was that the chief of engineers was authorized to make arrangements with him for the transfer of his maps and journals to the government, and to secure his further services. Thus Mr. Nicollet found himself designated to undertake, the next season, under government employ, and with abundant means to carry out his projects, a final expedition to the Northwest for the purpose of completing his map. To this expedition was attached Lieut. J. C. Fremont, chief assistant in topographic and astronomic work, Mr. Charles Geyer, botanist, M. de Montmort, a French gentleman attached to the Legation at Washington, and Mr. Eugene Flandin, a young gentleman from New York. The eventful career of Fremont may be said to have commenced with this expedition, and Mr. Nicollet retained him a: an assistant when afterwards he was engaged at Washington i reducing his astronomic observations and drafting his final maj

Two years (1838 and 1839) were given to field examinatio under these auspices. The second season Mr. Nicollet had, leaving Fort Pierre, in Dakota, a party of nineteen persons,

cluding Lieut. Fremont, Mr. Geyer, and Capt. Belligny, an officer of the French army who wished to see the Indian country, thirty-three horses and ten carts. The years 1840 and 1841 were spent at Washington, where Mr. Nicollet had rooms for his work in the Coast Survey buildings on Capitol hill, and lived, with Fremont, in Mr. Hassler's own house near at hand. Gen. Fremont, in his "Memoirs," gives many pleasant reminiscences of his work here with Nicollet, and of the associations which they had with Nicollet's personal friends in Baltimore, where Mr. Nicollet frequently retired for rest and recuperation—for his health was now seriously impaired, and he was able to make but slow headway with his report. The map itself, executed under his immediate eye, as the astronomical computations were made determining the chief points in his itinerary, was chiefly drawn by Fremont and Lieut. Scammon, both of whom had been assigned to that work for the assistance of Mr. Nicollet.

His official superiors were planning larger things for Mr. Nicollet, while his more intimate friends saw with sadness the gradual but persistent decadence of his health. His map was completed in 1841, and submitted to Congress. The Senate ordered its publication under the direction of the Topographical Bureau. It was to be accompanied by a report embracing an account of the physical geography of the country represented, together with the most prominent features in the geology and mineral resources of other sections in the western part of the United States not embraced in the area of the map. Mr. Nicollet gave, in 1841, an account of his work, and of his plans, at the Philadelphia meeting of the Association of American Geologists and Naturalists, dwelling particularly on the geological discoveries he had made. He was now at work upon his report. He had the collaborative assistance of Dr. Harlan, Dr. Torrey (in Botany) and to some extent of Messrs. Conrad and Vanuxem of the New York Geological Survey, then recently instituted. But he was greatly delayed by ill health. The more extended explorations which were being planned for him had to be transferred to his principal aid, Lieut. Fremont, who, though then young, was ambitious, and withal certainly better qualified physically, for carrying out the designs of the Government in western exploration. Had Nicollet's health been equal to the task it is likely that the great interior of the North American continent west of the Mississippi, would have been ex-

plored through the leadership of a Frenchman, and the eclat of French spirit and enterprise which characterized the early exploration of that portion east of the Mississippi, would have been extended unbroken to the Pacific shores.

Mr. Nicollet, meantime, grew restless and repaired frequently to St. Mary's college, Baltimore. He was not in condition to reduce to shape the materials for his report, which were varied and interesting, involving much information concerning the aborigines. Mr. Sibley says that he knows that Mr. Nicollet contemplated, when his materials should be elaborated, a work of several volumes, relating to the geology, topography and geographical position of what is now Minnesota, and discussing many interesting topics connected with the Indian tribes, and with the mound-builders. The only publication which resulted from this mass of material, was that small volume which was printed by order of the Senate, dated Feb. 16, 1841, descriptive of his map, and published in 1843. The short report which accompanies the map was being printed. He was revising it, as it was returned to him for the purpose, but he never saw its completion in printed shape. He died in the fall of 1843, and the "Introduction" was left incomplete. Col. Abert, to whom the report is addressed, adds this explanatory note, dated Sept. 13, 1843:

> Thus far Mr. Nicollet had written of his introduction, when death put an end to his labors, and before he had been able to revise his report, which had been returned to him for that purpose, and also to add the astronomical observations upon which his calculations were founded. These observations form parts of his journals which are to be deposited in the Bureau of the Corps of Topographical Engineers.

Lieut. Warren speaks of having consulted these journals in 1857, when compiling a general map of the western territories for the Pacific Railroad surveys. He distinguishes the map of Nicollet, which is now a very rare and valuable document, as "one of the greatest contributions ever made to American geography."

Nicollet was rather an astronomer and geographer than a geologist, yet he made (then) important contributions to the small fund of geological knowledge which was possessed of the Northwest, and he laid out in the form of his general map, a basis for future geological examination better than any enjoyed by the central and southern states of the Mississippi basin. His map and short ex-

planatory report also serve as an invaluable perpetuating link, preserving with great accuracy, many aboriginal geographic details and uniting early French exploration with recent known data through the agency of an appreciative and accomplished French scientist.

When he last left the Northwest, after spending several weeks with general Sibley, at Mendota, he made his way, in the fall of 1839, to Bedford, Pa., to the home of his friends, major and Mrs. Taliaferro, where he remained through the winter, and where he was so feeble that he had to be carefully nursed and treated with the best medical attendance. It was doubtless during this visit that was made the small ivory painting, which has furnished the basis for the portrait which accompanies this paper. Two photograph copies (vignette size) were presented to the Minnesota Historical Society in 1867, by Maj. Taliaferro, and are now preserved in its archives. Of one of these this portrait is an enlargement. The original has the following inscription on the reverse side, in Maj. Taliaferro's own writing:* "Photograph from painting on ivory of J. N. Nicollet, 1836. Photographed 1867 and presented to the Minn. Hist. Soc. by Lawrence Taliaferro, Aug., 1867, R. T. Gettys, Bedford, Pa."

Of the last days of Nicollet we know but little. There is no doubt, however, from the statements of Gen. Sibley, and the facts recorded by Gen. Fremont, that his fine physical frame was over-taxed by the demands made upon it by the fiery spirit which animated it, and which drove him through the hardships and toils of his frontier campaigns. The burden which was upon his mind, again, arising from the lofty ideal he had formed for the publication of his scientific report to the Government, wore on him continually, and as time passed, and his nervousness did not diminish, but rather increased, and the accomplishment of his purpose receded from him as the months wore away, he became irritable and more and more prostrated. About this time, also, according to Gen. Sibley, through the hostility which yet pursued him on the part of some of his old associates in business affairs, he failed of election to membership in the Academy of Sciences, at Paris, an honor which he coveted. He had the support of

*This has been still further enlarged into a life-size oil painting, by Mr. B. S. Hayes, an artist of Minneapolis, and hangs in the office of the writer.

LaPlace, but the opposition of Arago, who was characterized by LaPlace as the "great elector of the Academy." This was a mortal blow and he faded away rapidly on learning of it, for he had been duly nominated by some of his scientific friends in Paris.

I fain would dwell on the beauties of such a character. It was an exotic plant, forcibly transferred from luxuriance to the comparative desert and harshness of our northwestern frontier. It bloomed for a short time, disseminating unstintedly its fragrance on the surrounding atmosphere, but the colds and common blasts of our unsuited social climate, though wholesome to the American-bred spirit, were unfit to nourish his delicate constitution, and he drooped, faded and disappeared, leaving to us a remembrance of a bright soul, a gleam of a pure character,—a wearied fire-fly struggling in the tempest, a rose that wasted its fragrance on the desert air.

GENESIS OF IRON ORES BY ISOMORPHOUS AND PSEUDOMORPHOUS REPLACEMENT OF LIMESTONE, ETC.

By James P. Kimball, Washington, D. C.

(Continued from the *American Journal of Science*, Vol. XIII, Sept., 1891.)

Progressive studies of stratiform iron-ores throughout the geologic series of stratified rocks, have led to a wide—almost universal—acceptance of explanations of their development as products of chemical transmutations, or epigenesis. So far as based on unquestionable chemical reactions, these explanations differ mainly as to their application to given occurrences of iron-ores. What may be termed the replacement theory, has been held during the last decade to have a wide application, especially on this continent, to iron-ores on horizons of originally ferriferous limestone and other calcareous material. However, the application of this theory may be restricted from considerations of synchronous, or immediately successive, accumulations of the two kinds of material—calcareous and ferriferous, it will obviously be much the wider if it may be believed that replacing salts of iron are often from extraneous sources, and that the process of replacement or chemical interchange is through circumstances of atmospheric and topographic, as well as stratigraphic

or lithologic, environment. This I have endeavored to show in a recent memoir. By way of continuation of that memoir I proceed to instance a number of examples illustrating the general points under discussion.

I. Iron Ores of the Sub-carboniferous Limestone of eastern Kentucky.

Pseudomorphous replacement of Sub-carboniferous limestone by reddish brown limonite was recognized by Shaler as the mode of occurrence and genesis of well-known developments in eastern Kentucky.* The source of iron salts is referred to overlying coal-measures, all more or less pyritous, and mainly consisting of siliceous sediments. Replacement has taken place unequally, apparently as circumstances of environment have varied. This has proceeded from without inward, that is, from above downward. Cross-fissures and anfractuosities throughout the mass attest contraction. The degree of chemical replacement of limestone is in measure of vertical sections of ore-deposits. These often rise above the general level of the top of the limestone, owing to comparatively even shrinkage or chemical erosion of the limestone through solvent infiltrations.

Occasion will be taken to refer to similar occurrences in Ohio on the same horizon.

II. Replacement of coral-rock (limestone), Cuba.

In tracing the genesis of some very remarkable isolated bodies of mixed brown and red hematite (turgite) occurring on the south coast of the eastern peninsula of Cuba, I described them in the year 1884 as replacements of limestone in the form of elevated and disrupted coral-reef, or only partially indurated coralline limestone.† The replaced masses of limestone still retain surfaces characteristic of planes of fracture such as may be observed in costal cliffs of emerged coral-reef. Indistinct casts of corallum partially transformed into hematite are occasionally found, the cells being filled with chlorite. The condition of form, therefore, almost indispensable to proof of pseudomorphous replacement, is not altogether wanting.

Some idea of the importance of the scale on which replacement in this instance has been effected may be formed from the fact that the ore-bodies referred to supplied during the year 1890,

---

*Geol. Surv. of Ky. 1876 [3] 16.

†*Am. Jour. of Sc.* XXVIII (3), 1884, 416.

not less than 362,068 tons of iron-ore, the product of a single operation, that, namely, of the Juragua Iron Company. This product was over one-quarter of the total imports of iron-ores in the United States for the same period.

The same examples of molecular replacement on a grand or petrographic scale will serve to illustrate dependence of this mode of epigenesis on circumstances of environment. These are seen to have been particularly favorable, as was also the extreme porosity or permeability of the original coralline material. Suffice it to mention (1) envelopment of masses of this material with basic eruptive diorite, rich in iron silicates; and (2) climatic conditions specially conducive to secular weathering of superficial rocks.

Some of the iron-ore bodies exhibit concentric structure, a result of progressive weathering—the same as exfoliation on a smaller scale—easily mistaken for quaquaversal dips. Numerous shrinkage fractures due to contraction incidental to alteration, as well as larger manifestations of mechanical fracture, are filled out with chloritic material from decay of the dioritic magma and detritus. Thus masses of iron-ore are reticulated with bands of chlorite.

Incidental to secular decay of the mantle of diorite enveloping masses of limestone, chemical interchange or double decomposition was effected between fixed calcic carbonate and dissolved iron-salts. Ferrous carbonate, directly passing into ferric hydrate, was left behind, and lime salts were dissipated. The partial dehydration of ferric hydrate into ferric oxide (turgite), the product of further alteration, may, as shown by Davies and Rodman, proceed from only slight elevation of temperature.* There is no evidence, however, that these ore-bodies have been deeply buried. Indirect replacement in this instance has therefore been under exposure to an oxidizing atmosphere.

The metasomatic development of the iron-ores at the base of the Sierra Maestra dates from an era no more remote than the Cenozoic, when this coast range was added to the island of Cuba.

III. Replacement of Carboniferous and Silurian Limestones, Colorado.

Mr. S. F. Emmons has shown extensive replacement of Lower Carboniferous and Silurian limestones to have resulted in occur-

Jour. Chem. Soc. II, IV, 69.

rences of iron-ore, a mixture of hematite and magnetite, in Breece Hill, and of limonite as well as a more or less ferriferous gangue of epigenic silver ores at Leadville, Colorado. Here transmutation has been effected between limestone or dolomitic material and iron sulphates through aqueous infiltrations from adjacent intrusive porphyry. In the decay of the porphyry is involved vitriolization of pyrite, contained in this rock up to four per cent. The process of deposition of silver-ores as well as of ferriferous material, as concluded by Emmons, "was a metasomatic interchange with the material in which they were deposited." That is, "the material of which they were composed was not a deposit in a pre-existing cavity in the rock" (limestone) but "the solutions which carried them gradually dissolved out the original rock material and left the ore or vein material in its place."*

Occurrences of limonite near Hot Springs, Colorado, as described by Mr. C. M. Rölker, also afford striking examples of replacement of limestone.†

IV. Replacement of Upper Silurian (Clinton) Limestones.

Parts of thin fossiliferous limestones of the Clinton group of strata are often replaced by red and brown ferric oxides from extraneous sources. In the Appalachians of southern Pennsylvania, for example, where I have long had opportunity of closely observing the mode of occurrence of these ores, especially in flanks of Tussey, Dunning's and Will's mountains, fossil-ores, so-called, rarely oolitic, occupy the weathered zone of highly fossiliferous beds of limestone intercalated with shales and sandstones. This replacement has been wrought especially in steep dips by infiltrations from drainage of adjacent ferruginous strata, particularly of an inferior series outcropping topographically higher in the flanks of these parallel wall-like ridges. At or near water level or drainage level, and in topographical positions unfavorable to weathering action, or to sources of infiltrations, replacement has been found to cease. Super-saturation as at water-level, and impenetration of solutions from topographical causes are equally unfavorable for this process.

In portions of limestone beds bordering ravines down the mountain-side, dissolution of limestone sometimes has failed above immediate drainage level to be attended with replacement

*U. S. Geol. Surv. XII, 1886, Pt. 2, 378, 540.
†Trans. Am. Inst. Min. Eng., 1885, XIV, 266.

of ferric oxide. Yet in such circumstances the limestone has given way to the dissolving action of passing waters, leached insoluble residues retaining its original structure, as well as moulds of fossils, occupying its place along with creepings from adjacent strata. Here transmission of seepage water has proved too rapid for other than solvent or destructive action to have become sensible.

Another local circumstance is also deserving of mention. It is this. Opposed to a rapid transmission of infiltrations in water-sheds between successive cross-ravines is a barrier known as Red Ridge. Constituted of a compact series of arenaceous argillite, this is locally developed at the top of the Surgent shales, and stratigraphically above, but topographically in front of, the plane of the ore-limestone. Near where this barrier is scored by cross-ravines, underground as well as superficial drainage has become accelerated. Preservation of Red Ridge from local erosion has therefore come to be regarded in Bedford and Huntingdon counties, Pennsylvania, as indispensable to a favorable development of the fossil-ore bed back of it, or to the absence of "wants." Of these the distribution and extent are thus mainly determined by conditions of underground drainage as affected mostly by topographical features. Gentle dips under steep slopes are for obvious reasons inconducive to infiltration.

The above remarks directly apply to the more or less hydrous fossil-ores of the Appalachian ridges in southern Pennsylvania, as distinguished from oolitic hematites, or dyestone ores, likewise developed in favorable circumstances on lower horizons of thin crinoidal limestones within compass of the Clinton or Surgent formations. Both types of ores, and often both series of developments, are generally referred to indifferently as Clinton fossil-ores. The stratigraphical relations between these two series of developments, even where both may be recognized in a single ridge or section, are extremely variable. In southern Pennsylvania, where the Clinton shales attain a thickness of nearly 1,200 feet, the fossil-ore bed is about 400 feet above the horizon of the Frankstown oolitic or dyestone ore, which in turn is about 300 feet above that of the block-ore, so-called. All of these ores owe their development, as I believe, exclusively to secular replacement of elevated parts of these limestones—not, as sometimes explained, to direct sedimentation in whole or in part. For

wherever oolitic iron-ores are developed within the Clinton series, they are found to graduate into non-ferriferous limestones, more or less crinoidal, and usually in circumstances only moderately favorable to weathering action. An equally significant fact is the absence of valuable iron-ores where the Clinton limestone, as in southern Ohio, is massive and unaccompanied by a considerable thickness of overlying shales. Wherever, on the other hand, the limestone occurs in numerous thin beds, and so alternates with more or less ferruginous shales; or again, wherever overtopped by shales, it seldom fails, especially in steep dips, to graduate unequally into oolitic hematite by replacement. Even in Ohio, where the Clinton group is represented by a single but comparatively thick limestone member under gentle dips, the upper portion of the limestone is sometimes replaced by hematite,* though of no economic importance. Imperfect replacement likewise occurs where the limestone becomes shaly and expands in thickness.

Non-ferriferous Clinton limestones, more or less magnesian, into which their associated iron-ores graduate, may be assumed to have been deposited in clear and moderately deep continental seas. That these seas were ramified by all but insulated land-surfaces is indicated by the abundance of intercalated siliceous sediments from sub-aërial rock-decay. It is sometimes held that these limestones, and at least the oolitic hematites developed upon the same horizons and passing into each other, were necessarily deposited together. Yet direct ferric precipitation from extremely instable natural solutions of ferrous salts cannot well be believed to have taken place so far from inland sources as where conditions existed favorable to the accumulation of non-siliceous and expansive limestones.

Again, notwithstanding the fact that the Clinton iron-ores merge into pure marine limestones, have they, on the other hand, sometimes been assumed to afford proof of wide-spread marshes. A theory of this kind, however, is likewise opposed by the necessity of attributing expansive limestones of the Clinton type to mid-sea, and inferentially deep-sea, deposition. And the objection still stands that ferric hydrate in suspension, no more than ferrous salts in solution, can have materially contributed to marine non-siliceous limestones. The conclusion therefore seems justified

*Geol. Surv. of Ohio, VI, 12.

that whatever considerable proportion of ferriferous material was deposited within compass of the Clinton limestones, was alternately deposited in the form of siliceous sediments represented by intercalations of shale. Such intercalations are common in Pennsylvania and Virginia. A less theoretical objection rests on the fact that the distribution of the Clinton iron-ores clearly depends on secondary, and wholly adventitious, conditions connected with topography and environment.*

The application to the Clinton iron-ores of the views discussed in the continued and present memoir, falls in with the conclusion of Mr. Aug. F. Foerste, published since the above was written.† Microscopic sections of Clinton, dyestone oolitic iron-ores from Pennsylvania, Georgia, and Ohio reveal, according to Mr. Foerste, all stages of replacement of calcic carbonate, both cement and oolitic granules, by ferric oxide, the granules being fragments of Clinton species of water-worn bryozoans. "In no case, however, was anything noticed leading to the opinion that concretionary segregation of iron had taken place either around the bryozoan fragments or otherwise. Simple replacement of iron-ore was the rule, the attack being made first on the exterior parts of the grains." According to the same observer similar occurrences are found throughout the Clinton belt wherever oolitic iron-ores are developed.

V. *Replacement of Carboniferous Limestones.*

Upon any theory of epigenesis of siderite, sphærosiderite, and sideritic limestone, their greater distribution would seem to be natural under conditions for their preservation unaltered, such as may be recognized in environments where atmospheric air is displaced by mixtures of hydro-carbon gases and carbonic anhydride, as in formations of the Carboniferous period.

The so-called upper limestone-ore in eastern Kentucky, is, like the Sub-carboniferous or lower limestone-ore of the same region, described by Shaler, a product of alteration of pseudomorphous siderite after limestone. This is a replacement of upper parts of the Ferriferous limestone dividing the Lower Coal Measures, and co-extensive with the same division of strata in western Pennsylvania, West Virginia, eastern Kentucky and southern Ohio, where although known under a common designation, it is

*See Cut. by W. M. Chauvenet, Report Tenth Census XV, 1886, 396.
†Am. Jour. of Sc. XLI, 1891, 28.

also sometimes otherwise identified. According to Orton, this is the Gray limestone of Newberry, the Putnam Hill limestone of Andrews, the Ferriferous limestone of the same author, and the Gray and Hanging-Rock limestone of Orton. The iron-ore, with which parts of this limestone are replaced, both in the form of siderite and of its altered product, is identified with the Clarion ore and Buhrstone ore of western Pennsylvania, the Baird ore of the Hocking Valley, the Limestone-ore of southern Ohio and the Upper limestone-ore of north-eastern Kentucky. Over 200 blast-furnaces in these regions have drawn a supply of iron-ores from this particular horizon.* The average thickness of the replacements in southern Ohio is, according to Orton, about 10 inches, and further to the north about 8 inches, though said by Hunt to be often two or three times these averages, as in Vinton County.†

Superior portions of the Upper and Lower Freeport limestones of the Lower Coal Measures are likewise commonly replaced with siderite. This passes by alteration into limonite, sometimes in the form of concretionary blocks or nodules from exfoliation or weathering of prismatic blocks, separated by contraction due to chemical transformation. Several horizons of sideritic limestone are identified in the same series in Pennsylvania, West Virginia and Maryland, more or less distinctly graduating into non-ferriferous limestone. Among similar occurrences in the Lower Barren measures is the Johnstown siderite or ferro-calcite, identified with the Mahoning sandstone group.

Mr. Bayard T. Putnam, referring generally to the limonites of the Coal Measures of Pennsylvania, remarks that they occur along the outcrops of limestone-beds, and are in general simply the weathered outcrops of seams of carbonate-ore.‡

Above the horizon of the Sub-carboniferous limestone in Ohio, which has been shown to be replaced in part with siderite or its drivatives, that is, between this horizon and that of the Ferriferous limestone, several limestones of the Conglomerate series are likewise apt to be replaced with siderite in a more or less altered state. Such occurrences are notably the Zoar or Blue

---

*Orton, Rev. of Stratigraphical Geol. of eastern Ohio, Columbus, 1880, 29.

†Min. Res. of the Hocking Valley, Boston, 1881, 44.

‡U. S. Census, 1886, xv. 202.

limestone of Newberry, and the overlying Gore limestone of the Hocking Valley—both members of the Mercer group of strata.

Many well known horizons of siderite in Pennsylvania and bordering States have been described by Stevenson. The Mount Savage ore-group of the Conglomerate series is worthy of mention.* One plate or more of siderite occurs in the Mauch Chunk red shale. In many places local lenticular stratiform plates of siderite extend for a few hundreds to a few thousands of feet with a thickness up to four feet. In the Vespertine of Greenbrier Co., of Virginia, an occurrence of this kind has been described by Rogers, and more recently by Mr. W. N. Page.† Comparatively thin, lenticular or stratiform developments of this description may be assumed to be complete replacements of non-persistent limestones of estuarine origin.

Incomplete replacements of Carboniferous and Sub-carboniferous limestones of the Appalachians are, on the other hand, devoid of terminal edges, or other well defined demarcations such as appertain to lenticular beds conformable to the configuration of hydrographic basins. They are thus perceived to be wanting in characteristics of sedimentary or metamorphic deposits. This obviously would not be the case, if these developments were primarily due to mechanical or chemical deposition in the natural order of succession of beds by which they are enclosed. That they do not occupy pre-existing cavities produced by mechanical or chemical erosion is likewise certain from the fact that they sometimes merge into limestone. That they are not crystalline, or characterized by other phenomena of segregation, is conclusive negative evidence of some other origin. Thus, there seems to be no alternative but to consider these developments due to molecular replacement of limestone, of which mode of origin indeed there is no lack of positive and direct proof. Hence, inductively, again the conclusion that complete or strictly pseudomorphous replacement of limestone has been wrought in the case of stratiform developments of siderite and its derivatives, the iron-ores still retaining perhaps physical features of the original limestone in common with stratified deposits.

---

*Second Geol. Survey of Penn. KK.
†Trans. Am. Inst. Min. Eng. 1888, Extract, p. 4.

VI. Limonites (and crystalline iron-ores) of the Lower Silurian limestones.

That epigenic relations of some sort subsistbetween the limonites and the Lower Silurian limestones with which they are associated throughout the Appalachian valleys, was distinctly pointed out by W. B. Rogers over half a century ago. Their relation with ferruginous shales and sandstones alternating with the limestones is almost equally intimate. Not only was the epigenic or secondary origin of these limonites recognized by Rogers, but their mode of occurrence, that is—not as consecutive members of formations between which they outcrop and often appear to be imbedded, but as irregular accumulations comparatively shallow or altogether superficial. Sometimes lining, so as to occupy, enlarged fissures of stratification for a limited extent, they are still liable to be mistaken for regular or bedded deposits. Others, occupying in like manner enlarged fissures of cleavage or jointing in limestone, are sometimes assumed to be of the nature of segregations or mineral lodes. But their most common occurrence is in what is often described as superficial basins or other depressions on imperfectly drained surfaces and slopes upon a limestone floor, in proximity to lime stone, or within compass of its extended lines. This superficial association of limonite with the Silurian limestones themselves is sometimes considered to be simply owing to the cavernous condition of limestone, and to its liability to unequal erosion; whence the occurrence of local depressions, or sink-holes produced by subsidence, which have eventually become repositories of iron-ores from purely adventitious precipitation of ferric hydrate from passing waters. Pre-existing caves and crevices are likewise assumed to be so filled out with this deposit, or even by mechanical accumulations or "in-washes" of ferriferous material.*

To the general, or even a wide, application of such a view to the occurrence of important deposits of iron-ores serious objections are opposed. First, caves and cavities of this kind have been produced by solvent action of circulating water. Second, whatever insoluble products, including ferric hydrate, are separated from moving waters remain in suspension and finally escape. Third, possession of superficial depressions by detritus, calc-schutt, etc., prevents them from becoming open receptacles of

*Newberry; School of Mines Quarterly, Nov. 1880, Reprint p. 16.

unmixed chemical precipitates. Displacement of detritus must therefore precede separate deposition of homogeneous material, except by molecular replacement of limestone surfaces, calcareous detritus and calc-schutt. Physical displacement happens, if at all, by means of torrents, from which again no chemical deposition takes place except possibly by replacement, or at least only for a time. Important deposits of limonite free from detrital admixture, even of clay, ordinarily, at least preclude an explanation of their mechanical accumulation in pre-existing cavities.

Yet it is true that among the great variety of circumstances of environment and topography in which development of limonite has taken place on horizons of Lower Silurian limestones, instances there are where caves, cavities and enlarged crevices, once channels of rapid transmission of waters, have eventually been obstructed by falls of rock or otherwise, and, so cut off from drainage, have finally become quiescent reservoirs of mineral waters. In this way vacant spaces in calcareous beds may in some instances have become repositories of uninterrupted deposition of ferric hydrate either by precipitation, or by indirect replacement of limestone surfaces or calcareous contents. Limonite as sometimes occurring, and bearing evidence of having probably been formed in this way, has proved not uncommonly more enduring than the limestone itself, the destructive erosion of which it has survived in the form of outlying masses.

Ordinary accumulations of limonite thrown down in caverns, sink-holes and other depressions along with detritus, within the limestone ore-belt of Pennsylvania, have been well characterized by Mr. d'Invilliers.* Some of the obstacles in the way of a belief that pre-existing cavities often afford lodgement to important ore-deposits have been aptly stated by Emmons.†

Unaltered siderite in irregular shaped masses, sometimes occurs in the midst of limonite in ore-banks upon horizons of the Lower Silurian limestones as in Columbia and Dutchess counties, N. Y.; at Richmond and West Stockbridge, Mass., and at a few points in Pennsylvania and Virginia. These occurrences afford whatever grounds be found for a theory of original deposition of concentrated ferrous carbonate, intermittent, that

*Second Geol. Surv. of Penn. An. Rep. 1886, IV, p. 418.
†Trans. Am. Inst. Min. Eng., 1886, Ex. p. 5.

is, and even concurrent with sedimentation of the material of these massive limestone formations. Any change of sedimentation, such as contemplated in this theory, even if chemically supposable, would have resulted in lenticular configuration of siderite, or of its derivatives, a feature as above pointed out, probably possessed by siderite only in the case of complete or pseudomorphous replacements of lenses of limestone.

I have, in a previous paper, described lenticular occurrences of siderite at Burden, Columbia county, N. Y., on the horizon of a thin non-persistent and probably estuarine Lower Silurian limestone.* Whatever theory be entertained of their epigenesis, this must be perceived to be closely connected with overlying clastic ferruginous accumulations, the whole series occupying in-shore depressions in an undulating bottom overspread with calcareous material. In the paper referred to, these basin-like deposits, which in point of identification with Silurian members, are, I believe, so far as known without parallel in this country, were substantially explained as probably instances of *physical* replacement of limestone by ferriferous accumulations, graduating upwards into ferro-calcareous grits. The transgressive character of these grits appears from the fact that their development is limited to the basins themselves. Their thickness in any given vertical section is proportional to the thickness of the ore. The grits as well as the siderite are distinctly lenticular. The siderite was considered as a metamorphic product from reduction of ferric hydrate in reaction with commingled organic matter.

Having since come to the conclusion, through a critical examination, in another place followed out, of the several theories of epigenesis of siderite to be found in treatises and text-books, that all are at variance with chemical observations, or opposed by objections on physiographic grounds, I am now forced to believe that these interesting occurrences require a different explanation. They seem, indeed, to present no exception to the explanation of epigenesis of siderite by chemical replacement of alkaline monocarbonates, but on the contrary to afford striking examples of complete or pseudomorphous replacement of limestone beds.

Indirect replacement of limestone (II) by limonite at the Hurst ore-bank, Wythe Co., Va., has been graphically described by

*Am. Jour. of Sc. XL, 1890, 155.

Mr. Benton.* A useful section of six feet by this observer shows beneath the soil (1) limestone, with crevices filled with limonite; (2) limestone softened and decomposed, with crevices containing more limonite than No. 1; (3) meshwork of limonite almost completely replacing the limestone, and including residual ochre and fine sand; (4) complete replacement of limestone by honeycomb ore. Reticulation of limestone by limonite is seen to be progressive downwards until no remnants of limestone are left except in the form of insoluble residues occupying druses. These afford some measure of the contraction incidental to replacement.

Another striking example of the same kind given by Prof. Dana, has been referred to in the memoir, of which the present pages are by way of continuation, namely, in the Cone ore-bank at West Stockbridge, Mass.† Its description by this observer is as follows:

"Several layers had become wholly replaced by pure limonite, and one of these so changed was a yard thick. Some surfaces of the limestone were intersected by cracks, making areas three to six inches across, as represented in the figure; each crack having a border of limonite either side, an inch or so wide."‡

The same authority is cited by Mr. Prime for direct replacement of limestone by siderite ultimately weathered to limonite, namely, at Richmond, Mass.§ This occurrence, like others observed by Prime at Balliet's ore-bank near Allentown, Pa., and in another ore-bank near Hellertown, both in close relation to the Calciferous limestone and schists, is, as concluded by him, an instance of "alteration of the limestone to carbonate of iron particle by particle, or so to term it, a pseudomorph by replacement." The same writer attributes the limonites of the Calciferous limestone and schists in a general way, to alteration of ferrous carbonate produced by reaction of ferrous sulphate with calcic carbonate, both diffused and massive.

Remnants of notably pyritous material have been observed in many of the limonite workings of the Green mountain belt of Lower Silurian limestones and their southern extension, especially

---

*Rep. Tenth Census XV, 1886, 275.

†See Am. Jour. of Sc. XLII, 1891, p. 234.

‡Am Jour. of Sc. XIV, 1877, 136. Several excellent cuts illustrating the transition of limestone into iron-ores have been given by Mr. Chauvenet, Rep. Tenth Census XV, 1886, 292, 296, 297, 299.

§Am. Jour. Sc. IX, 1875, 140.

in intercalated or adjacent schists. Numerous analyses by the Second Geological Survey of Pennsylvania indicate the presence of sulphur in almost all of the ores of the same belt in that State. The dissemination of visible pyrite throughout undecomposed parts of both limestone and schists is also noteworthy. This seems to be in about the same minute proportion that ferrous carbonate is often similarly represented. The epigenesis of the latter is probably from pyrite. But hitherto the most remarkable evidence of pyritous material in the development of limonites associated with the same limestone series has been found in Alabama. In that region concentrically weathered or foliated masses of limonite isolated on the hill-tops by erosion of enclosing clay, the residuum of decomposed schists, sometimes retain nuclei or cores of undecomposed and highly pyritous rock. Central portions of other masses of limonite consist of siderite. Hence the not uncommon occurrence in limonite workings in limestone of ribs, masses and nuclei of siderite, ferro-calcite or limestone, from incomplete replacement, or incomplete subsequent alteration. Hence also similar occurrences of pyritous residuums in limonite developments in adjacent or transition schists.

In given instances, be the mode of replacement of limestone by ferrous carbonate what it may, whether from styptic or chalybic solutions, or whether originally or eventually introduced into Siluro-Cambrian limestones, in the lower member of which series (Calciferous) limonites have been so extensively brought to light in Appalachian valleys, there seems much reason to conclude, as sometimes held, that in the course of chemical erosion of the limestone and of decay of related schists, very considerable accumulations of residual limonite have resulted from alteration of diffused ferrous carbonate or pyrite, not exceeding two and one-half per cent., to stable ferric hydrate. Parts of the same series exposed to weathering or erosive action, and commonly below the full thickness, seem, in certain instances at least, to bear some proportion to the thickness of related accumulations of limonite. That is, the vertical range of the residual limonite seems to be in proportion to the thickness of limestone eroded, or rather to the measure of its shrinkage. Yet along with the escape of dissolved lime and magnesia salts in measure of chemical erosion, there is also dissipation of iron salts.

According to Lesley, limonite or pipe-ore, so-called, has a

stratigraphic range in Huntingdon County, Pennsylvania, near Warrior's Mark, of at least 1,250 feet. The whole thickness of the Calciferous—Chazy—Trenton series of limestones to the bottom of the Hudson River group, there attaining its maximum development in that State, is estimated by the same authority at 7,750 feet. A thickness of 6,000 feet of this series, as estimated by Prof. A. L. Ewing, has been removed from the Nittany Valley anticlinorium to form that valley, or at least 1,000 feet in vertical range, mainly by chemical erosion.*

McCreath's analyses have shown ferrous carbonate up to 2½ per cent. to be widely distributed in Lower Silurian limestones. The question arises when this was introduced—whether before deposition of succeeding schists or afterwards?

That this anhydrous salt was not directly deposited seems on chemical grounds almost certain. Is it then exclusively a product of replacement of calcic carbonate through solutions of iron salts from extraneous sources, and introduced subsequently to envelopment with ferro-siliceous sediments? Or, is it, in part at least, the product, practically in *loco originali*, of reactions between calcic carbonate in place and vitriolizing particles of pyrite, originally reduced from ferrous sulphate in sea-water through remnants of animal matter in accumulating calcareous sands?

The researches of Dr. A. A. Julien into variation of decomposition in the iron-pyrites series, led him to the conclusion that the original condition of iron sulphides along the Appalachian belt was that of pyrrhotite. To whatever degree, in that case, this mineral may have survived sub-aërial rock-decay, and been accumulated along with Lower Silurian sediments, would it serve as an extremely productive source of iron salts, through decomposition by carbonated waters, including alteration into marcasite and pyrite.

Even this initial transformation, as indicated by Bischof,† is attended by elimination of 25.54 per cent. of iron, and by contraction of volume not less than 32 per cent. as estimated from relative densities. Hence promotion of permeability in the containing rock through development of cavities. From surplus iron extracted by carbonated waters is doubtless developed ferrous carbonate, by reaction with calcic carbonate, or else ferric

*See Geol. Surv., Pa. T_3, pp. 422, 424, 454.
†Cavendish Edt. III, 455.

hydrate—as determined by atmospheric environment. This reaction may be assumed to be common both to limestone and adjacent transition schists, and even less closely related siliceous schists.

Iron sulphides, sometimes visible in sound Lower Silurian limestones, seem to be developed in about the same minute proportion that ferrous carbonate is often revealed by analysis. Limonite developed by epigenesis on horizons of these limestones and of adjacent schists commonly affords traces of sulphur, as pointed out by Mr. Prime. Much larger proportions of iron sulphide are notably developed in the schists.

It may therefore be concluded that both immediate and extraneous sources have contributed to fixation of ferrous carbonate as now found in parts of these limestones and associated schists; and that iron was received by these sediments in a carbonated atmosphere before or during their consolidation as well as afterwards.

This conclusion seems to be in line with Dana's* numerous observations in western New England and eastern New York, as well as with those of the Second Geological Survey of Pennsylvania, and to fall in with certain general deductions of Mr. Prime† and of Dr. Julien.‡

Besides limestones of the Siluro-Cambrian series, other limestones of the Silurian and Devonian periods give identification to occurrences of epigenic limonitic iron-ores. These are irregular shaped masses often described as lenticular (but in an opposite sense of that term as applied in this memoir) between limestone and adjacent ferruginous strata. Thus occupying bordering divisions of strata, they not infrequently assume to partial view semblance of interstratified deposits with which they have sometimes been confounded.

Such relations, however, point more or less distinctly to replacement of calcareous material through essentially superficial agencies, and to circumstances of attitude and environment favorable to epigenesis of limonite. These circumstances are ordinarily less obscure and complex than those which govern the

---

*Besides the several papers by Prof. Dana already cited, touching the present subject, may especially be mentioned one on Berkshire Geology, (Berkshire Hist. and Sc. Soc., Pittsfield, 1886.)

†Am. Journal of Sc. LX, 1875, 432.

‡An. New York Acad. Sc. III, 1886, 393, 399.

distribution of accumulations of iron-ore connected with the lower series of limestones, mainly on account of the distinct configuration and undisturbed relations of the accumulations themselves.

VII. Replacement of Crystalline iron-ores.

According to Lesley and d'Invillers the famous magnetite deposits at Cornwall, Pennsylvania, like the developments of brown hematite on the same horizon throughout the Great Valley, were originally a formation of Lower Silurian magnesian limestone beds.

"It may safely be said," as remarked by these observers, "that the Cornwall ore-mass has experienced three stages of development; being originally a formation of lime-shales; then becoming a great brown hematite formation; and finally a magnetic ore-formation."*

The advanced metamorphism of the original ore-replacement from limonite, or perhaps from siderite, to magnetite, is a phenomenon which there is much reason to believe, is connected with local doleritic intrusions along the edge of the Pennsylvania Mesozoic, as also in the case of other occurrences of magnetite on the same horizon at Boyerstown, Dillsburg and elsewhere in the same State.

Replacements of metamorphic limestone by other types of crystalline iron-ores have recently been observed by me in St. Lawrence County, N. Y. Here the Calciferous limestone has become crystalline, and its ore-replacements have become metamorphosed into red hematites or anhydrous ores of the specular type. At Pierrepont, highly crystalline specular ore, of splendent lustre, occurs in white metamorphic limestone of Calciferous age.

Taken in connection with my previous memoir on the present subject, the foregoing facts, here very briefly considered, tend to prove that replacement of Palæozoic limestones, and other calcareous material, including calcic carbonate from decay of siliceous schists, has been wrought indifferently from both infiltrating chalybic and styptic waters, through surrender in each case of a weak base like ferrous oxide for a strong base like lime. I have also sought to indicate some of the circumstances of atmospheric environment, topography or vicissitudes governing preservation, or—on the other hand—alteration of the product of

*An. Rep. of the Geol. Surv. of Penn., for 1885, 1886, p. 539.

direct replacement; and to attach what is conceived to be due significance and importance to such circumstances.

Chemical replacement of limestone by ferrous carbonate, it is hardly necessary to remark in review, proceeds from surfaces of cleavage and stratification, wherever penetrated by infiltration of atmospheric waters from neighboring permeable ferruginous rocks like schists and shales; or, again, from surfaces and interstices of rocks, wherever calcic carbonate is produced by decomposition of silicates. Or, still again, solutions of lime and iron salts from one or the other source, give scope to similar and successive reactions. Hence transmutations within compass of both limestone and adjacent schists. Mixed detritus from both kinds of strata, and overspreading considerable surfaces below the level of development or outcrops of such strata, also give place to like reactions. Hence numerous shallow deposits of limonite at the base and on slopes of Appalachian ridges. Much of the ferric hydrate which appears due to tardy precipitation at considerable distance from sources of iron-salts is doubtless from indirect replacement of limestone schutt.

VIII. *Replacement of Cambrian Limestones, Lake Superior region, and Missouri.*

The notable occurrences of crystalline iron-ores at Iron Mountain, Shepherd Mountain, and Pilot Knob in Missouri, within developments of stratiform porphyritic petrosilex (hällaflinta) was ascribed by Pumpelly, in the year 1872, to replacement of limestone.* Development of the petrosilex was also supposed to have resulted from chemical processes of replacement. However this may be, it is not difficult to imagine development of petrosilex from a siliceous limestone, or from a limestone intercalated with siliceous matter, concurrently with replacement of the calcareous material by iron-ores. Developments of this kind may be regarded as akin to the jaspery foliations of petrosilex along with crystalline ores in the Lake Superior region, the genesis of which by replacement of calcic carbonate has recently been traced by other geologists.

The relations of specular or hematite schists in the Lake Superior region to siderite, and the phenomena of its original development and distribution have recently been treated, first, by

*Geol. Surv. of Missouri, 1873; Iron Ores, 26.

the lamented Prof. R. D. Irving, and later by Mr. D. H. Browne, and by Mr. C. R. Van Hise.*

The conclusions of the present memoir seem, as may be claimed, to strengthen the probability that occurrences of siderite and ferro-calcite, like those described by these authors as the immediate source of hematite in the Penokee-Gogebic range of Wisconsin and Michigan, are of the nature of chemical replacements of limestone, and calcareous shales and grits more or less carbonaceous. Such developments are doubtless remnants of sideritic material, of which the greater part has been further altered into brown and red hematite successively.

As indicated by these writers themselves, from solutions of ferrous salts, replacement of calcareous material has been effected according to local conditions determining circulation and interception of these infiltrations. That this was once, or at least in part, direct, is shown by the development of siderite. Products of indirect replacement like ferric oxide proceed as in other instances either from spontaneous oxidation of the replacing carbonate, or from its tardy alteration. The part taken by dykes in the interception of drainage has particularly been shown by Van Hise.

Replacement of limestone by siderite, and subsequent alteration of this epigene product are opposite phenomena incidental to essentially different atmospheric environment. Carbonic anhydride, or reducing gases, or a mixture of both, which may be assumed to have prevailed concurrently with the first process, or rather wherever this was set up, eventually must have given way to an ordinary oxidizing atmosphere. The association of carbonaceous strata sufficiently attests this point.

FOREIGN EXAMPLES OF REPLACEMENT OF LIMESTONE BY IRON-ORES.

I close the present memoir with a few brief illustrations of replacement of limestone by iron-ores in well known and important developments in several parts of Europe. As such most of these have been distinctly recognized.

IX. Replacement of Carboniferous limestone, England.

The Carboniferous or Mountain-limestone series of the northern and north-midland counties of England, as in other parts of that island—especially in South Wales, consists of alternations of

*Am. Jour. Sc. XXXII, 1886, 255; XXXVII, 1889, 32, 299.

thick limestones with thin shales and sandstones. The limestones are horizons of siderite and hematite, of which the larger developments are irregularly distributed within compass of the calcareous strata. Phillips* has given a selection of cuts which well serve to illustrate the phenomena of indirect replacement of limestone by hematite through alterable ferrous carbonate, as pointed out by Smyth,† and as attested by the presence of fossils, identical with those of the limestone, partially converted into brown oxide.

X. Replacement of Mesozoic limestones, England.

The iron-ore occupying horizons of estuarine limestone of the Lower or Bath oolites at the top of the Upper Lias series in Northamptonshire abounds with shells and corals converted into ferric hydrate. As animal life could not possibly have existed in waters charged with iron salts to the degree apparently indicated by the ore, Mr. Samuel Sharp concludes that the iron must have been introduced by infiltration after the deposition of the sedimentary material.‡

From a microscopic examination, Sorby concluded that Cleveland ironstone of the Middle Lias of Yorkshire has been derived partly from mechanical deposition, and partly from subsequent chemical replacement of originally deposited calcic carbonate, "which probably thus served to collect together from associated ferruginous non-calcareous beds a large part of the iron" contained in this ore. This is particularly proved by pseudomorphous siderite after aragonite penetrating molluscus shells originally composed of that form of calcic carbonate.§

Lower Liassic beds of calcareous siderite or ferro-calcite occur in North Lincolnshire as upper members of a series of limestones and shales, and characterized by a great abundance of *Gryphaea arcuata*. The ore-series consists of alternations of unaltered ironstone with thin limestones, together aggregating, according to a section by Mr. George Dove, 16 feet in thickness. The ore, as described by Mr. D. Adamson, is intercalated with ferriferous limestone carrying from 8 to 16 per cent. of iron.‖

*Ore-deposits, 1884, 164.
†Memoirs Geol. Surv. of Gr. Britain, Parts I-IV, pp. 18, 19, 25.
‡An. Jour. Geol. Soc. 1870, 376; Judd, Mem. Geol. Surv. Gr. Br., 1875, 136.
§An. Jour. Geol. Soc. 1879, 84.
‖Jour. Iron and Steel Inst. 1876, 327.

Lower Cretaceous, Wealden or Middle Neocomian calcareous strata in the same county, give place to oolitic brown ironstone which is described as highly fossiliferous as well as calcareous. The same strata are overlain conformably by the Lower Greensand series of arenaceous shales, with which is imbedded limestone passing into ironstone.*

XI. Replacement of Liassic limestone Luxemburg and Lorraine.

The oolitic limonites of Luxemburg and Lorraine, equivalent with the ores of the Cleveland district of Yorkshire, and of the same general character, bear likewise evidence of replacement of limestone. Highly calcareous, as practically shown by their self-fluxing property, they contain remnants or nuclei of unaltered limestone, as well as numerous molluscus shells transformed into limonite.†

XII. Replacement of Mesozoic limestones, central France.

Some very striking exhibitions of the class of phenomena which it is here sought to illustrate, are afforded on a large scale by well known deposits of limonite and hematite within the development of Jurassic and Cretaceous limestones in the ancient province of Berry, now included in the Department of the Cher, in central France. I refer to occurrences recently studied by M. de Grossouvre.‡ A graphic description by this engineer leaves scarcely room for doubt of the origin of these deposits by indirect replacement. In the elaborate memoir now referred to, no attempt is made to trace the process of epigenesis beyond the action of solvent chalybic waters in excavation of limestone, and in deposition of ferric hydrate in its place. So far from being the simplest statement of the process of indirect replacement, this explanation is upon the assumption of chemical erosion of the limestone as a distinct act antecedent to precipitation of ferric hydrate, or, however insupposable, of anhydrous ferrous carbonate. Hence, as imagined, the formation of caves, cavities, basins, etc., in limestone, followed by the filling of such receptacles with products of chemical precipitation. The same reasoning has often been applied to similar occurrences in this country and elsewhere. Reasons in general against such an assumption have already been given. The theory of molecular

*Bauerman, Met. of iron, 1872, 91.
†M. A. Habets, Jour. Iron & St. Inst. 1873, 285.
‡Ann. des Mines x, 1886, 311-416.

replacement precludes any such intermittent action on the part of a single agency.

XIII. Replacement of Tertiary Limestone, Hesse.

Epigenesis of oolitic iron-ores in Tertiary limestone of Rhenish Hesse has substantially been described by Tecklenburg as replacement of an oolitic limestone, the source of infiltrations of iron salts being an upper ferriferous limestone of the same series.*

XIV. Replacement of Pre-palæozoic crystalline limestones, Banat.

Some striking examples of replacement of crystalline limestone at Russkberg (Banat) by siderite passing into hematite on the one hand, and into magnetite on the other, were in other terms described by Mr. Rafael Hofmann, in the year 1854.†

Like the other more important iron-ore developments of the Carpathians, these are upon horizons of pre-palæozoic limestones.‡

Among other well-known developments of siderite and its derivatives in continental Europe within limestone strata, suffice it in passing to mention those of Carinthia and Carniola; and notably those of the Styrian Erzberg near Eisenerz in Austria; also those of the Rhenish province of Coblentz and Siegen in Germany.§

Commonly regarded as epigene products, these have usually been described by German authorities in various terms as Stöcke,|| Lagerstöcke, Gangstöcke, and Flötze, sometimes of direct deposition successive in relation to enclosing strata, sometimes as mechanical fillings or "in-washes" of pre-existing spaces; and, again, as chemical segregations. In most of the conspicuous instances named, circumstances of environment and topography are such as to indicate more or less clearly molecular replacement of limestone or dolomite.

M. Sibertzy, of the Geological Survey of Russia, considers cer-

*Zeitsch, Berg—Hütten—und Salinen Wesen XXIX 1881, 210.
†Gangstudien, II, 468.
‡Von Hauer—Geol. Oest.—Ungar. Monarchie, 1875, 194.
§Senft. Geognosie 1876, 451; Von Hauer loc. cit. 223.
||Dr. E. Reyer truthfully says that Geology and the miner call that form, as to whose form nothing is known, a Stöck. (Berg-u-Huettenmannische Jahrbuch XXIX, 1881, 26.)

tain iron-ores of that empire as products of replacement of Permian and Carboniferous limestones. Another Russian authority, M. P. Zemiatschensky, entertains similar views in respect to iron-ores of central Russia.*

XV. *Mediterranean iron-ores as replacements of limestones.*

1—Iron-ores of Bilbao, Spain.

No more remarkable developments of iron-ores can be instanced than those of the Biscayan province of Spain. These ores, known far and wide under designations of localities of numerous workings on the flanks of Mt. Triano, include those of Somorrostro, Triano, and Matamoras, from which immediate localities, according to Mr. Gill, over 2½ millions of tons was produced in 1882, or 93 per cent. of the whole product shipped from the port of Bilbao during that year.

These ores are of several amorphous types and gradations, including limonites, turgites and hematites, some of the latter verging upon the specular variety. They are of different degrees of purity, inversely proportional to their tenor of earthy silicates; and according to the degree, first, of replacement of limestone, and, second, of alteration from the condition of ferrous carbonate, from which all types and gradations have evidently been derived.

These important iron-ore deposits occupy the horizon of limestone, especially of a formation interposed between overlying fossiliferous argillaceous limestone, and a lower limestone underlain by variegated and micaceous grits, containing nodular sphærosiderite, the whole series, of Middle Cretaceous age, being much disrupted and dislocated. The ore, wrought in places to depths of over 100 feet, greatly fluctuates in thickness, owing to inequality in vertical range of replacement, whence obviously the uneven or billowy surface of the limestone floor, as described by Gill and others. In other places the limestone is fully developed, no replacement having been effected. Again, the whole vertical range of the limestone is represented by ore, while at still other localities a lenticular bed of unaltered limestone separates the so-called *campanil*, clearly a hematitic or transition product of alteration of siderite—more or less incompletely transformed,

*Cited in Bibl. of iron-ores. Geol. Nat. Hist. Surv. of Minnesota, Bull. No. 6, pp. 320, 334.

from the underlying *vena dulce*. This is a soft limonite passing into turgite and also graduating in places into a harder variety known as *vena dura*, in which abound pseudomorphous rhombohedrons of hematite, after siderite.

The shaly blue limestone, containing *requienia lævigata*, and giving place to ore-bodies on the north side of the divide between the Nervion and the Somorrostro rivers (Mt. Triano), presents a continuous outcrop on the south side, and forms the crest of the mountain. The *vena dulce*, or gallery ore, is described as the character of ore deep under cover; *campanil*, the choice or shipping ore of the region, under moderate cover; and *rubio*, a worthless variety in exposed ledges. The latter is a sideritic, cellular, cherty limonite, forming outliers or crags, evidently corresponding to the upper edge of disrupted and highly tilted masses of the *requienia* limestone, weathered and leached by atmospheric action without the aid of underground moisture, and without protection of cover, but passing into *vena* on attaining cover. In both brown and red-ore mines siderite occurs in blocks as cores or nuclei of altered products.

The source of ferrous salts yielding more or less alterable ferrous carbonate in contact with limestone, appears to have been overlying, now mostly obliterated, ferriferous and pyritous sediments, of which remnants are preserved. Unequal conditions, perhaps in original composition of the ore-limestone, but certainly as to attitude and environment, have led to unequal development of ore-masses, some of which, according to Gill, having the semblance of mountains of ore, proving mere shells of good ore with nothing but siliceous material behind them. Changes of volume, as unequal replacement and chemical alteration have advanced, may be believed to have been adequate to produce no small part, if not the whole, of the disruptions and dislocations, so marked a feature in the stratigraphy of the region.

Though some of the phenomena here referred to have been differently interpreted by M. Barson* and M. Baills,† the descriptions given by Gill‡ furnish abundant evidence of sideritic replacement of Cretaceous limestone strata, and of subsequent alteration into limonite and hematite more or less advanced as condi-

*Rev. Univ. des Mines, IV, 1878, 648.
†Annales des Mines, XV, 1879, 209.
‡Jour. Iron and Steel Inst. 1882, 63.

tions for weathering action have been more or less favorable, especially as regards the intervention of moisture.

2. Iron-ores of Elba.

The specular iron-ores of the island of Elba, which have often been instanced in text-books as an example of eruptive or sublimation deposits, a conclusion questioned by G. Vom Rath in the year 1870,* have since been described by Lotti of the Geological Survey of Italy, as in part altered products of replacement of calcareous rocks with which a chemical interchange of materials has taken place, in conformity with the law that the more easily soluble minerals are replaced by the less soluble.†

3. Algerian iron-ores (Tafna).

Among well-known Algerian iron-ores are those of the Tlemcen district, near the western border of the province of Oran. These ores, commercially known as Tafna ores, are, as described by M. Pouyanne,‡ hematites occupying the horizon of Liassic limestone, which rests unconformably on ancient crystalline schists. While masses, large and small, of unaltered limestone and siderite are unequally distributed in all of the workings, these masses all furnish evidence of gradual and progressive transition into hematite, while specular and magnetic oxides occur as products of further alteration. Other deposits imbedded with Tertiary strata are made up of detritus from the Liassic ores first mentioned.

Washington, D. C., March 21, 1891.

CRITERIA OF ENGLACIAL AND SUBGLACIAL DRIFT.

By Warren Upham, Somerville, Mass.

The purpose of this short paper is to call the attention of glacialists to the means of discrimination of the portion of the drift which, at the time of final melting of the ice-sheet, was enclosed within the ice and therefore is called englacial drift by Pres. Chamberlin, and the portion which was subglacial, lying under the ice. It is hoped that the availability of the criteria here mentioned will be discussed by others, and that we may attain the most useful methods of observation and determination, in all parts of our drift-bearing area, concerning the question whether a large

*Jahrb. für Min. 1870, 786.
†Emmons, Trans. Am. Inst. Min. Eng. 1886. Ext. 8.
‡Ann. des Mines IX, 1876, p. 81.

fraction of the drift, or only a small amount, was contained within the ice-sheet, becoming superglacial by ablation, at the time of its departure.

Englacial Till. The following characters have seemed to me, in examination of the drift deposits of New Hampshire and other New England states, and of Minnesota, Iowa, the Dakotas, and Manitoba, to distinguish the englacial till, reaching from the surface to a variable depth, as compared with the lower subglacial till.

1. More plentiful and larger boulders are usually enclosed in the portion of the till that was englacial. Sometimes many of them are only partially embedded at the surface.

2. These boulders and the smaller pieces of rock are mostly angular or subangular. While being carried along in the ice-sheet, the englacial drift was not subjected to attrition, which accounts for the large size and unworn character of its rock fragments.

3. The englacial till has commonly a somewhat more gravelly and sandy and less clayey composition, owing to the washing away of much of its finer material by the drainage of the glacial melting.

4. It has a looser texture and is much more easily excavated This portion of the englacial drift was allowed to fall loosely when the ice disappeared. The subglacial till, on the other hand, being compressed by the vast weight of the ice-sheet, became very hard and compact, whence comes its popular name, "hard pan.'

5. The effect of weathering, by which the small ingredient of iron in the till has become changed next to the surface from protoxide combinations to the hydrous sesquioxide, giving a yellowish color, strongly in contrast with the darker gray and bluish color of the unweathered portion below, often is limited at the plane that separates the readily permeable, loose englacial till from the comparatively impervious subglacial till.

6. Between the two, there is frequently a layer of subglacial stratified gravel and sand, from a few inches to a few feet thick.

Subglacial Till. Characteristic features of till accumulated beneath the ice are, conversely, the prevailingly smaller size and glaciated shapes of the enclosed boulders and fragments, its larger proportion of clay or very fine rock flour, its remarkable hardness, and in many sections the cessation at its top of the coloration due to weathering.

Another criterion of subglacial till is the position of its oblong

stones, generally with their major axes approximately parallel with contiguous glacial striæ and with the course of movement of the ice sheet, and the embedding of flat stones with their flat sides nearly horizontal, or, where the accumulation rises in a prominent mass, as in drumlins, taking a parallelism with the slopes of the surface. In the englacial till stones of these shapes are less abundant, because of their exemption from glacial wearing, and they have no observable order of arrangement.

Furthermore, the subglacial till often exhibits, especially in sections of drumlins, a peculiarly bedded structure, in parallelism with the surface. Though boulders, gravel, sand, and clay are thoroughly commingled, the deposit is imperfectly laminated and tends to separate and crumble into thin flakes. This is frequently noticeable in a fresh excavation, but is most distinctly seen after a few weeks of exposure.

Mr. Hugh Miller has observed similar structural features of the subglacial till over large tracts of northern England;* and the discrimination of the englacial and subglacial till, relying on most of the characters here noted, was probably earliest pointed out by Dr. Otto Torell, of Sweden.†

A partial stratification by water within the till, producing sometimes thin layers of gravel, sand, or clay, inconstant in character and thickness and usually of short extent, or often only a distinct approach toward the formation of such layers, is occasionally observed in both the englacial and the subglacial till, probably more frequently in the former; but veins of gravel and sand, of such extent as to yield a sufficient supply of water for wells, are more common in the latter, or, as before noted, at the plane between these deposits. The obscure stratification seems attributable to seeping water during the deposition of the till, whether subglacial or englacial and superglacial, while the definite and larger gravel veins were formed in small and temporary subglacial water courses.

Both deposits contain boulders and other drift derived from near and from remote rock outcrops. Local topography determined the relative abundance of these portions, and probably also whether the ratio of far travelled material is greater in the en

*Report of the British Assoc. for Adv. of Science, Montreal, 1884, pp. 720, 721.

†Am. Jour. Sci., III, vol. xiii, pp. 76-79, Jan., 1877.

glacial or in the subglacial till, for it seems to vary in this respect in different districts. During the progress of the accumulation of the subglacial till, it was supplied mainly from the lower part of englacial material, in which boulders and fine drift of near origin were more abundant than higher up in the ice. Hence, as a whole, doubtless the subglacial till has more local material, though differing little in this respect from the basal part of the drift within the ice-sheet. The streams depositing kames and osars, as I believe, brought these sediments largely from the upper and more remotely derived portion of the englacial drift, and also transported them for the greater part long distances, thus wearing the boulders and gravel to subangular and rounded forms. Therefore, in the order of their percentages of distances of transportation, the subglacial till is generally lowest, and the englacial till next, while the stratified gravels, sands, and clays brought by streams from the ice were successively deposited, each mostly beyond the preceding and farther from their sources.

Perched Blocks. When the ice-sheet was melted away, its enclosed boulders were dropped, and some of them, lying as conspicuous objects upon the surface, are strown sparsely over the prairies or are perched, apparently where they might be easily dislodged, on the slopes and crests of hills and mountains. Occasionally these perched blocks are of great size. Two found by Dr. G. M. Dawson on the eastern foot-slope of the Rocky mountains, about 3,300 feet above the sea, measure respectively 42 by 40 by 20 feet and 40 by 30 by 20 feet. Other blocks in the same region extend up to the height of 5,280 feet, and they all were derived from the Archæan area east and north of lake Winnipeg, some 700 miles distant.*

President Chamberlin has described remarkable belts of abundant superficial boulders associated with terminal moraines in Illinois, Indiana, and Ohio.† These boulders are almost exclusively crystalline Archæan rocks, and are thus known to have been transported across a distance of at least 300 to 500 miles from the north. They show that here and there in the ice-sheet rock masses, derived from remote hilly or mountainous tracts, were borne forward high above the land; and that on the approximately level country of these states only the lower portion of the ice contained much drift derived from local rock formations.

*Geol. Survey of Canada, Report of Progress for 1882-83-84, pp. 147-149 C

†Bulletin, G. S. A., vol. i, 1890, pp. 27 31.

Most of the very plentiful boulders usually present in the hills and ridges of the terminal moraines were doubtless brought as the highest part of the englacial drift.

Kames, Osars, and Valley Drift. That a large amount of drift was carried along in the ice-sheet and became exposed on its surface during its final melting, seems to me clearly proved, not only by the thickness of englacial till according to the criteria before noted, but also by the various deposits of assorted or modified drift. Perhaps the most interesting class of these deposits is that which consists of prolonged ridges of irregularly bedded gravel and sand, often extending in a series many miles, sometimes 20, 50 or even 100 miles or more in length. These ridges usually have steep sides and a narrow arched crest of variable hight. Associated with them, and especially with the terminal and marginal moraines of the ice-sheet, are mounds, hillocks, and short ridges likewise composed of gravel and sand having a confused stratification, often somewhat anticlinal in conformity with the slopes of the surface. Both the very long gravel ridges or series of ridges, and the very short ridges, hillocks, and knolls, were formerly classed together, and were called kames, eskers, or osars, but a useful discrimination has been proposed by McGee and Chamberlin, in accordance with which the term *kames* is now restricted to the gravel hillocks, knolls, and ridges of slight extent, while the long ridges are named *osars* or *eskers*.*

Precisely the same explanation of the mode of formation of the osars was reached independently fifteen years ago by Dr. N. O. Holst in Sweden† and by the present writer in New Hampshire.‡ Four years earlier, as I afterward learned, nearly the same view had been first published by Prof. N. H. Winchell, in Minnesota.||

*W J McGee, in the Report of the International Geological Congress, second session, Boulogne, 1881, p. 621. T. C. Chamberlin, in the Third Annual Report of the U. S. Geol. Survey for 1881-'82, p. 299; and Am. Jour. of Science, III, vol. xxvii, pp. 378-390, May, 1884. The article last cited presents many bibliographic references, and shows that the term osar (pl. osars), in this Anglicized form, has long been in common use by Jackson, Hitchcock, Desor, Murchison, and other authors.

†"Om de glaciala rullstensåsarne," Geologiska Foreningens i Stockholm Förhandlingar, vol. iii, 1876, pp. 97-112. This paper is reviewed by Dr. Josua Lindahl in the American Naturalist, vol. xxii, pp. 589-591 and 711-713, July and Aug., 1888.

‡"On the Origin of Kames or Eskers in New Hamshire," Proc. A. A. A. S., vol. xxv, 1876, pp. 216-225. Geology of N. H., vol. iii, 1878, chapter i. Proceedings, Boston Society of Natural History, vol. xxv, 1891, pp. 228-242.

|| Geol. and Nat. Hist Survey of Minn., First Annual Report for 1872, p. 62, etc.; Second An. Rep. for 1873, p. 194. Proc. A. A. A. S., vol. xxi, for 1872, p. 165.

During the Champlain epoch, as the time of disappearance of the last ice-sheet has been named by Dana, its superficial melting was rapid throughout the warm portion of each year, while the subglacial melting went on at a very slow rate through both winter and summer, the same as it had been during the entire epoch of glaciation. Owing to the rapidity of the melting on the ice surface, and to the amount of englacial drift thus exposed and subjected to erosion and transportation, we believe that the subglacial stream courses already existing were inadequate for the drainage, and that they were mostly obstructed and closed by the transportation and deposition of modified drift. The waning ice-fields were then deeply incised by brooks and rivers pouring over them in the descent to their border and to the adjacent land lately uncovered by the glacial retreat. Hydrographic basins of the ice-sheet probably extended 50 to 200 miles or more from its margin, resembling those of a belt of country along a sea coast; but the glacial rivers, and their large and small branches, had much steeper gradients than those of the present river systems on the land surface, and often or generally they flowed in deep ice-walled channels, more like cañons than ordinary river valleys. Much englacial drift, which had become superglacial, was washed away by the rains, rills, and small and large streams from the ice surface; and the osar gravel ridges are the coarsest sediments progressively deposited near the ice-front in such channels which were cut backward into the retreating edge of the ice by the superglacial streams.

The best development of osars on this continent, scarcely inferior to that of Sweden, is found in Maine and has been thoroughly explored and studied by Prof. George H. Stone, who concludes that the material forming these long ridges, also the short ridges and knolls called kames, and the valley drift, or stratified gravel, sand, clay, and fine silt, spread along the river courses and on the lowlands, were all supplied chiefly from the englacial drift.* This origin seems to me also true for the kames, osars, and valley drift which have come under my observation in New Hampshire, Vermont and Massachusetts, and in Minnesota, Manitoba, and adjacent portions of the Northwest. In a paper read

* Proceedings of the Boston Society of Natural History, vol. xx, 1880, pp. 430-469. Proc., A. A. A. S., vol. xxix, 1880, pp. 510-519. Am. Jour. Sci., III, vol. xl, 1890, pp. 122-144.

last August before the Geological Society of America. I show that the volume of the drift contained in the last ice-sheet when it was melted from these states and province appears to have ranged from very little on some tracts to the thickness of at least forty feet on other tracts. On the average, I believe that it was not less, but probably considerably more, than my estimate of its amount in New Hampshire, namely, the equivalent of a uniform sheet of drift six or seven feet thick.

In Great Britain, however, the material of the kames and other modified drift is thought by Prof. James Geikie to have been derived almost wholly from subglacial drift through the action of streams flowing beneath the ice-sheet; and he believes that there was very little englacial drift, quite too little to permit the englacial derivation of the stratified drift which is affirmed by Torell, Holst, and others in Sweden, and by Dana and many others who have studied the drift of North America. But another eminent British glacialist, Mr. G. W. Lamplugh, in a very complete and valuable discussion of the drift deposits of Flamborough Head and other parts of England, published this year, thinks that the ice-sheet which moved outward from Scandinavia and the highlands of Scotland and northern England, sweeping across the low area that is now the bed of the North Sea, and then encroaching on the Flamborough coast, was charged with a large amount of englacial drift, not only Norwegian and Scottish boulders, but also marine débris with fossils, gathered up into the ice from ground that had been previously and is again now the sea bottom.*

In this country, we owe to Prof. James D. Dana the earliest enunciation, more than twenty years ago, of the doctrine that the ice-sheet contained abundant drift and deposited it during the final melting, partly as unstratified and partly as stratified drift;† and only a few years later this opinion was also published by Prof. N. H. Winchell, with especial emphasis on the effect of the superficial melting to cause this drift to become superglacial.‡ Both these authors appear to claim that a larger proportion of the whole volume of the drift was englacial at the close of the Glacial

---

*Quart. Jour. Geol. Society, London, vol. xlvii, 1891, pp. 384-431, with maps and sections.

†Trans., Connecticut Academy of Arts and Sciences, vol. ii, 1870, pp. 66-86. Manual of Geology, editions of 1874 and 1880.

‡Geological and Natural History Survey of Minnesota, First Annual Report, for 1872, p. 62. Pop. Sci. Monthly, vol. iii, 1873, pp. 293, 294.

period than I should be able, on the basis of my observations and the foregoing criteria, to admit. There were surely, as I think, extensive and thick deposits of subglacial till, besides some scanty subglacial beds of stratified gravel, sand, and clay; and the aggregate mass of the subglacial drift appears to me without doubt to exceed, and perhaps two or three times over, the mass of the ice-held drift.

Testimony of Existing Ice-sheets. Dr. N. O. Holst in his examination of portions of the margin of the Greenland ice-sheet, found extensive deposits of both englacial and subglacial drift, respectively characterized by angular and by glaciated stones and boulders. The largest accumulation of superglacial drift, which had been englacial, was observed on the southern edge of a lobe of the ice near Frederikshaab. The drift covering the ice surface here extends along a distance of nearly twelve miles, and reaches a half mile to one and a half miles upon the ice. According to Holst's Swedish report of his observations, summarized in translation by Dr. Josua Lindahl,* the quantity and upper limit of the superglacial drift at this locality are as follows:

Its thickness is always greatest near land, but here it is often quite difficult to estimate its actual thickness, as it sometimes forms a compact covering, only in some fissures showing the underlying ice. This uneven thickness of the moraine-cover offers to the ice a proportionally varying protection against the sun. It thus happens that the unequal thawing moulds the underlying surface of the ice into valleys and hills, the latter sometimes rising to a hight of fifty feet above the adjacent valley, and being so densely covered with moraine material that this completely hides the ice core, which, however, often forms the main part of the hill.

Farther in on the ice, the moraine gradually thins out. At the locality just referred to, the moraine-cover, 3,000 feet from land, measured several inches in depth; still the ice was seen in some bare spots. Beyond 4,000 feet from land, the moraine formed no continuous cover, and at 8,300 feet it ceased entirely, with a perceptible limit against the clear ice. Only some scattered spots of sand and gravel were met with even a few hundred feet farther in on the ice. Dr. Holst estimated the average thickness of the moraine taken across its entire width near its eastern end at one to two feet. The limit between the moraine-cover and the pure ice is always located at a considerable though varying elevation above the edge of the inland ice. In the instance of the above-mentioned moraine it varied between 200 feet and 500 feet.

Terminal moraine ridges in process of accumulation on the

*Am. Naturalist vol. xxii, pp. 589-598 and 705-713, July and Aug., 1888.

thinned border of the ice, were seen in several places, sometimes. as shown by the following quotation, consisting chiefly of subglacial drift, elsewhere of englacial drift.

The border moraines north of the Arsuk fjord ice-river are visible far out on the sea off Ivigtut. Dr. Holst examined one that surrounds the southernmost strip of land at a distance from land of about 2,000 feet. It is not one continuous ridge, but consists of several disconnected portions arranged in a semi-circle. One of these portions was about 200 feet wide and thirty five feet high. This moraine was mainly a ground-moraine, probably forced up by some elevation of the ledge under the ice.

Another border moraine to the north of Kornok's northern ice-river, was of a different character. The stones, at least at the surface, were greatly in preponderance over the gravel. They were angular and of varying size. The moraine showed some arcuations, but taken as a whole it was parallel to the land. In some exceptional instances it approached closely to the land, even so as to touch one of the projecting points, but generally it was located some distance away from land. Its width was estimated at 100 feet, and its hight at more than fifty feet; it should be remembered, however, that it might have had a core of ice. Its length was about one and a half mile. South of this moraine, and farther in on the ice, were seen three more moraines, the greatest one extending about 1,000 feet in length. Two of them were parallel, one inside the other.

Still more impressive testimony of a large amount of englacial and finally superglacial drift is given by Mr. I. C. Russell in his description, as follows, of the Malaspina glacier or ice-sheet lying between the base of Mt. St. Elias and the ocean.

This is a pleateau of ice having an area of between 500 and 600 square miles, and a surface elevation in the central part of between 1,500 and 1,600 feet. It is fed by the Agassiz, Seward, Marvine, and Hayden glaciers, and is of such volume that it has apparently displaced the sea and holds it back by a wall of débris deposited about its margin. All of its central portion is of clear white ice, and around all its margins, excepting where the Agassiz and Seward glaciers come in, it is bounded by a fringe of débris and by moraines resting on the ice. Along the seaward border the belt of fringing moraines is about five miles broad. The inner margin of the moraine belt is composed of rocks and dirt, without vegetation, and separated more or less completely into belts by strips of clear ice. On going from the clear ice toward the margin of the g[illegible] e finds shrubs and flowers scattered here and there over the surfa[illegible] r'arther seaward the vegetation becomes more dense and the flowers cover the whole surface, giving it the appearance of a luxuriant meadow. Still farther toward the margin dense clumps of alder, with scattered spruce trees, become conspicuous, while on the outer margin spruce trees of larger size form a veritable forest. That this vegetation actually

grows on the moraines above a living glacier is proved beyond all question by holes and crevasses which reveal the ice beneath.*

The abundance of superglacial drift on this small ice-sheet in Alaska, and its comparative scantiness on the greater part of the border of the extensive ice-sheet in Greenland, seem readily explained by the recent and present rapid decrease of the Alaskan ice, while that of Greenland is probably now increasing and the climate growing somewhat colder.†

Both these ice-sheets lie on or near very mountainous districts. It will be of the highest interest to glacialists to obtain similar observations of the Antarctic ice-sheet, for most portions of its vast expanse seem to flow out into the sea from areas of low land, more nearly representing the basin of the North Sea, from which, according to Lamplugh, the confluent Scandinavian and Scottish ice moved upward over the eastern shores of England, bringing much englacial drift derived from that lower area. In like situations, too, far from mountainous or even notably hilly country, are the localities which have afforded to me the greatest estimated thickness of the englacial drift, as about forty feet adjacent to the Altamont moraine on the Coteau des Prairies in southwestern Minnesota,‡ and about the same amount where currents of the ice-sheet converged from the northeast and northwest at Bird's Hill near Winnipeg, Manitoba.§ In each of these places the englacial drift is largely derived from the neighboring low region.

THE WINNEBAGO METEORITE.

By E. N. EATON, Ames, Iowa.

In the August number of the GEOLOGIST professors Torrey and Barbour again publish their analysis of the Winnebago county meteorite. The analyses thus far published vary so greatly that I hesitatingly add a preliminary one made by myself

*"An Expedition to Mount St. Elias, Alaska," National Geographic Magazine, vol. iii, 1891, pp. 185, 186.

†AM. GEOLOGIST, vol. viii, pp. 145-152, Sept., 1891.

‡Geol. and Nat. Hist. Survey of Minnesota, Ninth Annual Report, for 1880, pp. 322-326; Final Report, vol. i, 1884, pp. 603, 604.

§Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. iv, for 1888-89, pp. 38-40 E.

soon after the "fall" and published in the *Aurora*,* a magazine edited by the students of the Iowa Agricultural college.

For comparison these analyses will be placed together.

RECORDED ANALYSES OF THE WINNEBAGO METEORITE.

	†Eakins Govt. Surv.	Eaton	Torrey and Barbour matrix	‡entire.
Nickeliferous iron	19 40	20.22		45.00
SiO_2	35.71	23.88	47.03	25.86
FeO	§15.12	26.71	¶29.48	16 18
MgO	24 00	25.91	2.96	1.63
Al_2O_3	2.08	2.62	2.94	1.62
CaO	1.41	Tr.	17.58	9.67
S	2.13	Tr.		
K_2O	.80	Tr.		
Ni	.13	Tr.		
Cr_2O_3	.08	Tr.		
	100.86	99.34	99 94	99.96

In their last article professors Torrey and Barbour do not give the percentage of metal. but in a former article under the same analysis of matrix it is stated to be 45%.** In the fourth column the analysis is calculated on this basis.

It will be observed that Torrey and Barbour's analysis contains over twice as much metal, almost seven times as much lime and less than one-fourteenth as much magnesia as that reported by Eakins. Do the sections of the aerolite show such diversity in chemical composition? That it is not altogether homogeneous is evident from a microscopical examination. The nickeliferous iron occurs in nodules of varying size while there is no regularity in the distribution of olivine. triolite, ferrous oxide or other constituents. Also in the fragments the surface is oxidized in an extremely thin layer while on the larger masses it is somewhat thicker. That this variability is not conspicuous in dealing with larger masses is indicated by Torrey and Barbour obtaining the identical specific gravity as that reported by Kunz (3.608)†† while my own (3.67) is nearly a medium between Kunz and Eakins (3.804 at 28.5C.).‡‡ My chemical analysis corresponds quite closely with Eakins.

*Vol. XIX July, 1890, p. 62. †Am. J. Sc. Vol. 140, 1890, p. 312.
‡Allowing 45 per cent. for metal.
§Some of the iron combined as FeS hence per cent. FeO too large.
In original article estimated as Fe_2O_3 (29.68 per cent.) ¶ Ferric oxide.
**Am. Jo. Sc. Vol. 139, p. 521.
††Trans. N. Y Acad. Sc. Vol. IX, No. 8, May-June, also AMERICAN GEOLOGIST, Vol 6, p. 249.
‡‡Am. J. Sc. Vol. 140, p. 312.

In reviewing the facts presented by the analyses, one is inclined to doubt the veracity of the specimens upon which professors Torrey and Barbour made their analyses. In view of the number of counterfeit specimens that were exhibited soon after their value became known, some of which resembled the meteorite closely, a mistake of this nature might easily occur.

The specimens upon which my analysis was made were sent by Mr. Eugene Secor, of Forest City, a trustee of the Iowa Agricultural College, to Prof. Herbert Osborn, and are now under his care in the college museum. Other specimens were sent to me by parties in Forest City, and I think there can be no doubt as to the genuineness of the samples analyzed.

On the whole it would appear advisable that there be a careful revision of the work for such variability in chemical composition is unparalleled in the history of meteorites, and if true should have clear confirmatory evidence.

EDITORIAL COMMENT.

RECENT STUDIES IN SPHERULITIC CRYSTALLIZATION.

Constitution and origin of spherulites in acid eruptive rocks. WHITMAN CROSS. (Phil. Soc. Wash. Vol. IX, pp. 411-444.)

Spherulitic crystallization. JOS. P. IDDINGS. (Phil. Soc. Washington, Vol. IX, pp. 445-464.)

Mr. Cross found, in the investigation of spherulites and lithophysæ of Colorado that the views both of the German and the French and of the English petrographers were inapplicable and the schemes of classification were unsatisfactory. He sketches German opinion, from Vogelsang to Zirkel and Rosenbusch, with critical observations. In particular, the term "microfelsite" proposed by Zirkel and considered by Rosenbusch to signify a distinct mineral species occurring in scales and fibres and having a characteristic radiating spherulitic structure, Mr. Cross considers with Iddings, Teall and Brögger to be improperly defined. He rather inclines to the opinion that these substances consist of a "submicroscopic" intergrowth of orthoclase and quartz, and

that the fibers and scales in the ground mass of porphyries and rhyolites may be minute particles of feldspar indeterminable by existing means of research.

In a similar manner the term "petrosilex" is employed by the French petrographers, under the lead of Michel-Levy, in a loose way, as is admirably illustrated by the definition, "a partially amorphous magma impregnated with silica already individualized in a state of opal or chalcedony." Spherulites are supposed, by the same authority, not to consist of known minerals, unless they be quartz and feldspar, intergrown in the manner of pegmatite.

The result of the author's study of the Colorado material seems to show that indefinite substances, such as crystallites, petrosilex and microfelsite, have been assumed to be present unnecessarily in many cases heretofore, under the influence of preconceived ideas.

The chemical constitution of the pitchstone containing the Colorado spherulites shows, that on complete crystallization the rock resulting would be composed nearly two-thirds of alkali feldspar and a little more than one-third of free silica. The author coincides with Iddings in the description of Obsidian cliff, that, instead of being due to an arrest of crystallizing consolidation (supposed by all European authors) spherulites of the smallest size as well as the larger spherulitic masses, are due to the crystallization of some definite minerals from a magma, under special conditions. There are a few older crystals in these rhyolites which, at a period prior to the spherulitic, were formed from the magma and by their arrangement bring, out the fluidal structure. These took up the small percentages of lime, magnesia and iron oxides which analysis shows to exist in the pitchstone, forming phenocrysts of plagioclase, leaves of biotite, microlites of augite and trichites of magnetite. Mr. Cross examines specially the larger spherulitic masses, but he considers even the smallest to consist of definite and often identifiable minerals.

As to the origin of these spherulites, Mr. Cross supposes that amorphous silica plays an important role. First a colloidal substance, embracing the elements of silica and of feldspar, is supposed to be separated from the magma, this being "a local change in the character of the magma," but whose cause and attendant conditions Mr. Cross does not attempt to state. From this primary colloidal globule are generated amorphous silica in one di-

rection and feldspar in another, the latter taking radiated and branching forms under varying tension and viscosity in the magmatic mass. As the colloidal substance is further separated, the specialized growths go on *pari passu*, resulting in concentric zonal structures or in radiated spherulites, or imperfect arborescent forms—and sometimes in holocrystalline spherulites.

It is difficult to see, from the discussion, wherein Mr. Cross finds warrant for the existence of this supposed anterior, globular colloidal substance, or wherein his hypothesis enlightens or even embraces "the conditions favorable to or causing spherulitic growths," (p. 435) which he announces as its purpose. In fact it appears, from the statements of Mr. Cross, that the general magma, after the primary segregation of the phenocrysts of plagioclase, biotite, microlites of augite and grains of magnetite, had nothing left but the same elements that he deems characteristic of this colloidal substance, and it is perhaps reasonable to suppose the magma itself, *en masse* at this time was colloidal and generated the spherulites in the same manner as supposed for the isolated colloidal globules. It is only by assuming the minute primary globules of the magma itself as it existed just prior to the spherulite-forming stage, as the initial colloidal globules, that there can be, so far as we can see, any warrant for the hypothesis, and if the hypothesis be reduced to this, it is no hypothesis at all, for it only assumes a well-known condition of amorphous matter. Mr. Cross's discriptions are clear and comprehensible, and the paper, aside from its philosophy, is a valuable contribution to American petrography.

The paper of Mr. Iddings treats of a stage in spherulitization subsequent to that above described, viz.: the process of formation of the crystalline inter-growths and the characters of the crystals formed. It is based on a study of a new series of thin sections of the lithoidite of Obsidian Cliff, in Yellowstone Park, the sections presenting 26 examples of one phase of the rock. The new study in Mr. Iddings' opinion corroborates, and also extends the conclusions reached by the former research, adding three new minerals, tourmaline, mica and zircon, to this rock. Mr. Iddings likewise rejects, as he before ignored, the term "microfelsite," and believes it is demonstrable that even the finest of the spherulites are but very small forms of larger ones whose structure and composition can be observed.

The paper is taken up mainly with the record of facts descriptive of the micro-structure of the crystallizations seen in these spherulites. There is, however, a hypothetical underlying cause, or conception, which Mr. Iddings entertains as the initial condition precedent for the formation of spherulites, viz.: the presence and unequal distribution of water-vapor within the siliceous magma. This water-vapor seems to act, as presumed by the author, rather physically than chemically and to determine by its greater amount in localities the greater molecular mobility within the molten magma which locally permits crystallization. In other words the conception of the author is that where now exists a spherulite within the obsidian glass, originally was a local centre of greater hydration than in the magma in general. This condition precedent answers, in Mr. Iddings' hypothesis to the colloidal globule in Mr. Cross's, but neither of the hypotheses aims to account for the initiation of the actual crystallization.

At first glance there seems to be an obstacle to this assumed unequal distribution of hydric vapor, and it is the same in character, as that stated by Mr. Iddings against an unequal distribution of heat "throughout any considerable mass of the magma" (p. 446) viz.: *in the nature of the case*. Heat and hydric vapor, in their manner and degree of distribution, are, when both are present, if not identical, so intimately correlative that what may be assumed for one, may, perhaps, be assumed for the other. But it must be admitted that there is a fundamental distinction to be observed, in this case, between the presence and probable manner of distribution of heat and the presence and probable distribution of water-vapor. Heat, in a molten eruptive rock, is primary and essential and may reasonably be supposed not to present great variations throughout "any considerable mass," but hydric vapor is secondary and accidental, and may be supposed to be most abundant at those points where the molten magma may have been brought into contact with superficial waters. Such accidental contacts would, in the first place, cause a rapid and general diffusion of water-vapor through all the adjoining crust, as well as through the molten magma, and it would seem inevitable that some parts of the magma, even throughout "considerable masses" would be affected differently by its presence in differing amounts. Notwithstanding this distinction, however, in the nature of the origination of these two elements in the liquidity of the magma, it

must again be admitted that the very act of vaporization of water when brought into contact with a molten magma, would abstract heat locally from the magma, and that the local differences in the heat of the magma would extend *pari passu* with the production and diffusion of the vapor of water. Indeed these two progressive changes would almost exactly complement each other, and hence, again, the presence and the distribution of hydric vapor "through considerable masses of the magma" would not perhaps be any more unequal than the distribution of heat.

It must be understood, however, that here we are considering "considerable masses of the magma," throughout which compared with other considerable masses there may or may not have been differences of heat and hydric vapor. This is quite a different thing from the assumption of centres, or points (for each spherulite is supposed to have begun its growth at a point), disposed irregularly through the molten magma, at which there was, temporarily or continuously a greater amount of watery vapor than throughout the remainder of the mass. These spherulites are immensely numerous. Some are large, and some are microscopically minute, and sometimes they touch each other. There must, under the hypothesis of Mr. Iddings, have been an immense number of individual points, almost an infinite number, at which, though separated from each other by microsopic distances, there were maintained greater amounts of hydric vapor than in the intervening spaces. Such a conception of the manner of distribution of hydric vapor is unique and can hardly be accepted under the well-known laws of the diffusion of gases.

We cannot see as either of these authors has suggested—we will not say the cause but—the essential condition precedent of the formation of the spherulites in acid lava. Mr. Iddings' requirement that within the area of the developing spherulite there must have been greater molecular mobility than in the surrounding magma, is a step toward the solution of the problem. Whether this greater mobility depended on a colloidal secretion from the magma, enveloping the point at which the crystallization began, or on a point or a globule, within the magma, which enjoyed a preponderance of hydric vapor, or of greater initial heat, each one of which seems to us untenable, it is plain that the authors have made valuable and creditable contributions to American petrology, and that in

the research which they have conducted, their results have been reached independently, and anterior to all other petrographers.

In conclusion we would suggest that perhaps, if the initial step of the conjunction of two differing molecules into chemical union be admitted as the starting point, such as the molecules which make one molecule of orthoclase, there may have been developed enough heat to cause the similar union of two others, and that two others, *ad infinitum* or *ad finem*, thus promoting the local difference of heat required on which to postulate the local difference of molecular mobility. It seems that the initiation and the maintenance of the growth of spherulitic crystallization, in the same manner as of all other crystallization, must be sought for in the occult laws and relations of chemical affinity. It also seems that on physical attendant conditions depend the forms of growth which the crystallizing matter shall take on. It is necessary to seek for those physical surroundings in the magma, in the case of spherulites, which may have prevented the second and succeeding molecules of orthoclase from placing themselves alongside of their earlier brothers in accordance with the laws of the crystal system to which orthoclase belongs, and thus from building up a perfect monoclinic form.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geological and Natural History Survey of Canada, ALFRED R. C. SELWYN, *Director: Annual Report, New Series, vol. IV, for 1888-89.* Montreal: 1890. 8vo, pp. xxix, 1054; with three plates engraved from photographs, four maps, and a sheet of sections. Price, $2. The summary reports of the operations of the Survey during 1889, by the director and assistants, comprises 66 pages. The cost of the Survey during the fiscal year ending June 30th, 1889, was $100,607.96. Sales of the Survey publications in 1889 amounted to $2,909.57; and within this year the number of visitors to the Survey Museum was 18,300, being an increase of 886 as compared with the previous year. This volume also includes the following papers.

Report on a portion of the West Kootanie District, British Columbia, 1889. By GEORGE M. DAWSON. Numerous recent discoveries of valuable silver-bearing ores in the mountainous country adjoining Kootanie lake and the Upper and Lower Arrow lakes of the Columbia, led to the

geologic reconnaissance which is here described in 66 pages, with a map. These long and narrow lakes, measuring respectively about 64, 46, and 51 miles in length from north to south, and one to two miles in width, occupy basins that were probably preglacial river valleys of similar origin with the fjords of the coast. Of two soundings in the Upper Arrow lake, one showed a depth of 490 feet, and the other failed to reach the bottom at 720 feet. In the Lower Arrow lake the deepest of three soundings was 460 feet. Kootanie lake is probably deeper than either of these, but was not sounded. Their approximate hights above the sea are as follows: Upper Arrow lake, 1,390 feet; Lower Arrow lake, 1,380 feet; and Kootanie, 1,730 feet. The Gold and Selkirk mountain ranges rise steeply on each side of these lakes to elevations 4,000 to 9,000 feet above the sea.

A general section of the rocks exposed in these portions of the Cordilleran belt is as follows, in descending order:—

	Feet.
Greenish and grey schists, with many beds of limestone in the lower part	2,000
Limestone or marble, often banded with siliceous layers, and associated with black argillite and grey schists	2,500
Chiefly greenish schists, with some grey schists	4,050
Chiefly grey schists, and including some greenish schists, constituting, with the last foregoing, the Adams Lake series	8,650
Black, shaly or schistose argillites, with much dark limestone, both being often more or less micaceous, named the Nisconlith series, probably	1,000
Mica schists, gneisses, and marbles, completely crystalline and often highly siliceous, named the Shuswap series	5,000

The total estimated thickness of strata is thus 23,200 feet. No distinct unconformity is found throughout the entire section, but the lowest division is provisionally referred to the Archæan, while the higher formations, though destitute of fossils, are thought by Dr. Dawson to represent various periods through the whole Palæozoic era, from the Lower Cambrain up to the Carboniferous, inclusive. Besides these stratified formations, granites and granitoid rocks occupy a large part of the West Kootanie district, their principal area being the basin of the Lower Arrow lake.

Nearly all the metalliferous deposits occur in the stratified rocks. In the Shuswap series they are mostly galena, with some blende and pyrites, and are of low grade as to their content of silver. Rich argentiferous veins traverse the Adams Lake series and the next overlying limestones and argillite schists.

On the top of Toad mountain, which lies near the junction of the Kootanie river with the Columbia, at a distance of about twenty-five miles north of the international boundary, glacial striæ in bearings between S. 6 and 33 E. were found at the altitude of 6,990 feet above the sea. They are attributed by Dr. Dawson to an ice-sheet that was accumulated on the Cordilleran mountain belt in British Columbia, adjacent portions of the United States, and the Northwest Territory of Canada.

In almost exactly the same latitude, but about 170 miles farther west, similar southward glaciation is found on Loadstone Peak at a hight of 6,370 feet.

Report on an exploration in the Yukon and Mackenzie Basins, N. W. T. By R. G. McConnell. This memoir of 163 pages, with an index map of the country described, is based on observations during 1887 and 1888. The intervening winter was spent by the author at Ft. Providence, a post of the Hudson's Bay Company near the west end of Great Slave lake. Some idea of the vastness of the region embraced by this report may be inferred from the navigable extent of the Mackenzie river, on which this company's steamer runs about 1,300 miles, from Ft. Smith on latitude 60° to the Peel river at the head of the Mackenzie delta. Devonian rocks, in some localities yielding many fossils, form the greater part of the country bordering the Mackenzie below Great Slave lake; but on certain tracts they are covered by Cretaceous marine strata and Tertiary lacustrine beds. Boulder clay and other drift formations occur along the whole course of the Mackenzie, but only on the upper portion of the Yukon.

In many places on the Mackenzie, as also on the plains of Alberta and Assiniboia, the boulder clay or till rests on a great thickness, sometimes fully 150 feet, of preglacial gravels, which seem to be the analogue of the Lafayette formation of our southern states. These beds in the Mackenzie basin contain well rounded cobbles up to eight or ten inches in diameter, including many of gneiss and granite derived from the Archæan area far to the east. They are intimately connected with the boulder clay, and in one place were observed to alternate with it.

An appendix, filling 18 pages, gives meteorologic observations, taken twice each day from June 25th, 1887, to the same date of the next year. A single station, Ft. Providence, was occupied seven months, from Oct. 4th to the end of April.

Report of Exploration of the Glacial Lake Agassiz in Manitoba. By Warren Upham. pp. 156, with sections, and two maps. Reviewed in the Am. Geologist, March, 1891. An extract, treating of the history of this lake, has also been reprinted in this magazine. Two appendixes accompany this report, one giving courses of glacial striæ about Hudson bay, lake Superior, and westward, and the other tabulating altitudes determined by railway surveys in British America from Port Arthur west to the Pacific.

Report on the Mineral Resources of the Province of Quebec. By R. W. Ells. pp. 159. The growth and present condition of the various mining industries of this part of Canada are concisely stated, from information embodied in previous reports of the Survey and of experts, from articles in scientific journals, and from mining superintendents.

Report on the Surface Geology of Southern New Brunswick. By Robert Chalmers. pp. 92. The part of New Brunswick described in this re-

port borders the Bay of Fundy, extending from the Maine boundary on the west to the isthmus of Chiegnecto, uniting this province with Nova Scotia, on the east. A southern hilly and mountainous belt of crystalline rocks, some thirty miles wide, runs along the coast; and back of this is a low, broad Carboniferous area, much of it beneath the 200 *feet* contour line. River valleys, now partly submerged indicate that the country stood at a greater elevation, being not less than 200 feet higher, during late Tertiary time; but after the departure of the ice of the Glacial period it was for some time depressed about 220 feet, as is known by fossiliferous marine beds overlying the glacial drift, and the sea then covered the Chiegnecto isthmus. This subsidence agrees closely with that found by Prof. George H. Stone in Maine. From the depression the land was re-elevated considerably above its present level, this being shown by a bed of peat at a depth of about 80 feet under the Tantramar salt marsh at the head of the Bay of Fundy. The latest movement has been downward, but seems to have ceased. Sea cliffs, beach ridges, and salt marshes, show that now and at least for some centuries past the relative levels of land and sea have been nearly or quite stationary.

Preglacial decayed rock and beds of gravel on many tracts underlie the till, which is often thin or almost wholly wanting but occasionally attains a thickness of 50 or 60 feet. Drumlins, moraines, and kames occur somewhat as in the New England states, and the region is nearly everywhere profusely strown with boulders. The Leda clays and Saxicava sands extend to the hight of about 220 feet; and at greater elevations the district is prevailingly mantled with unfossiliferous beds of coarse gravel and sand, often irregular in their stratification and contour.

Chemical Contributions to the Geology of Canada, from the Laboratory of the Survey. By G. Christian Hoffmann. pp. 68. This report comprises a large number of analyses and descriptions of coals and lignites, natural waters, iron ores, limestones and dolomites, etc., with notes of about two hundred assays for gold and silver.

Report on the Mining and Mineral Statistics of Canada for the year 1888. By H. P. Brumel. pp. 93. The aggregate value of the mineral products of Canada during 1888 is tabulated as $16,500,000. Coal stands first, with value somewhat exceeding $5,000,000. The product of iron, so far as statistics could be obtained, was nearly $1,600,000: of gold, about $1,000,000: copper, $667,000; petroleum, $755,000; asbestus, $255,000. The total exports of mineral products during the year was $4,738,810, of which nearly three quarters went to the United States, and about one-tenth to Great Britain.

Division of Mineral Statistics and Mining: Annual Report for 1889. By Elfric Drew Ingall. pp. 124. The total mineral production during 1889 was $19,500,000. Each of the products before specified for 1888 shows an increase, excepting petroleum, which fell off about 20 per cent. The largest ratios of increase are for iron and asbestus, each of which advanced about 70 per cent.; and the value of the product of steel was

Fossil Resins; By CLARENCE LOWN and HENRY BOOTH, New York, N. D. C. Hodges, 1891, pp. XVI and 119.—4 plates.

Messrs. Lown and Booth have made a very creditable compilation of the literature of this subject. They cite and describe eight authorities from 1816 to 1876. They have apparently collected all the available literature and one is surprised with the result; a score or so of papers and *no more.* It seems almost incredible that so fascinating a subject should have received so small a share of attention. The lack of material may no doubt be responsible for this. The typography of the book is exceedingly bad.

Geological Excursions; 1860-1890. London, EDWARD STANFORD, 1891, pp. 571, fig. in text.

This valuable book, "A Record of Excursions of the English Geologists' Association made between 1860-1890," is ably edited by Messrs. THOS. V. HOLMES, F. G. S., and C. DAVIES SHERBORN, F. G. S. The membership of this association is not only composed of professional geologists but also of all persons who find pleasure in the various excursions which the Association takes year by year for the purpose of studying some section of country under the guidance of some local professional geologist. The present work is one descriptive of these various excursions and contains a brief account of the geology of each place visited.

New minerals from the Serpentine Belt at Easton, Pa.; By JOHN EYERMAN. (Acad. Natl. Sci., Phila. Oct. 26, 1891.)

The author announces the discovery of a number of minerals from the line of contact between the Serpentine rocks and the Calciferous (?) limestone near Easton, Penn. Ten minerals not heretofore known from this locality are described, of which topaz, hydromagnesite, chalcopyrite and graphite are the most important.

LIST OF RECENT PUBLICATIONS.

IV. *Excerpts and Individual Publications.*

From Japan to Granada: Sketches of Observation and Inquiry in a Tour Round the World in 1887-8. By J. H. Chapin. New York, 1889.

A Memorial Address on the Life and Services of Alexander Winchell. By M. W. Harrington. Published by the University of Michigan. 1891.

Stones for Building and Decoration. By George P. Merrill. New York, 1891.

A Sketch of the Physical Geography of Iowa, by R. E. Call. From Ann. Rep. Iowa Weather and Crop Service for 1890.

Notes on the Occurrence of Musical Sand on the Pacific Coast of the United States, by H. C. Bolton. From Proc. Amer. Assoc. Adv. Sci. Vol. XXXIX. 1890.

V. *Foreign Publications.*

Bulletins du Comité Géologique, St. Petersburg, 1890, IX, No. 7, contains: Compte rendu préliminaire sur les recherches géologiques dans les domaines Werkhué-Tourinskaya, Nijny-Toutinskaya et Bisserskaya, par A. Krasnopolsky; Compte rendu preliminaire sur les recherches faites en 1889 dans la partié septentrionale du gouvernement de Lublin et dans la région de la ligne du chemin de fer de Szpola-Umagne dans le gouvernement de Kiev. Par A. Michalski. IX, No. 8, contains: Note sur les travaux exécutés par l'expedition de Timane en 1890, par Th. Tschernyschew; Recherches géologiques faites dans le district de Novornskovsk du gouvernement d'Ekaterinoslav et quelques nouvelles données sur les depots tertiares inférieurs du bassin de la rivière Solenaia par N. Sokolov.

Mémoires du Comité Géologique, Vol. IV, No. 2, Allgemeine geologische Karte von Russland. Blatt 138. Geologische Untersuchungen in nordwestlichen Gèbiet dieses Blattes von A. Stuckenberg; Vol. V, No. 1, Carte Géologique générale de la Russie. Feuille 57. Moscou; Vol. V, No. 5, Dépôts Carbonifères et Puits Artésiens dans la region de Moscou par S. Nikitin; Vol. VIII, No. 2. Die Ammoniten der unteren Wolga-Stufe, von A. Michalski; Vol. X, No. 1, Le Tremblement de Terre de Verny, 28 Mai (9 Juin) 1887, par J. V. Mouchketow.

Bulletin de la Société Géologique de France. Paris. 3e Série, tome XVIII, No. 1, Mars 1890, contains: Le Permien dans l'Aveyron, la Lozère, le Gard et l'Ardeche, par M. G. Fabre; Grande faille du Zaghouan et ligne principale de dislocation de la Tunisie orientale, par M. G. Rolland; Description du Terrain crétacé dans une partie de la Basse-Provence, par M. Collot. No. 2, Mai, 1890, contains: Note sur le Système oolithique inferieur du Jura méridional, par M. Attale Riche; Géologie de l'Indie Française, par M. H. Léveillé. No. 3, Juin, 1890, contains: Note sur une Porphyrite à pyroxene par M. Camuset; Origine de l'Orographie de la Terre, par M. Tardy; Sur la présence, dans le Languedoc, de certaines espèces de l'étage e du Silurien superieur de Bohême par M. J. Bergeron; Succession des éruptions volcaniques dans le Velay, par M. M. Boule; Note sur la présence du Pleurodictyum problematicum dans le Devonien de Cabrieres et sur un nouvel horizon de Graptolites dans le Silurien de Cabrieres, par P. G. de Rouville; Echinides recueillis dans la province d'Aragon (Espagne) par M. M. Gourdon, par M. Cotteau; Remarques sur le nom générique d'Hipparion par M. A. Gaudry; Seconde note sur les Holothuridées fossiles du Calcaire Grossier, par M. Schlumberger; Note sur la Géologie de la Tunisie, par M. Le Mesle; Sur l'age relatif des Mammifères de Cernay, par rapport aux Vertébrés du même groupe déconverts en Europe et en Amérique, par M. le Dr. Lemoine; Etude stratigraphique et nouvelles recherches sur les Mollusques du terrain lacustre inférieur de Provence (Danien), par M. Caziot; Note sur les mines de Colar (Inde) par M. Léveillé; Note

sur le Barrémiem de Cabonne (Drôme), par M. G. Sayn: Sur la position stratigraphique de Charbons fossils du Piémont, par M. Fred. Sacco. No. 4, Juillet, 1890: Observations sur les dunes littorales de l'époque actuelle et de l'époque pliocene en Algérie et en Tunisie, par M. A Parran; Sur le fossile décrit par M. de Zigno sous le nom de "Anthracotherium Monsvialense," par M. A. Gaudry; Les Dunes maritimes et les Sables littoreaux, par M. le Dr. Labat; Sur la classification des Cératites de la Craie, par M. H. Douvillé; Note sur quelques Echinides du terrain crétacé du Mexique, par M. Cotteau; Note sur l'extension des Atterrissements Miocènes de Bordj-Bouïra (Alger), par M. E. Ficheur. No. 5, Aout, 1890: Étude sur les rapports des Mammifères de la faune Cernaysienne et des Mammifères crétacés d'Amérique, par M. Lemoine; Note sur le péristome du Phylloceras mediterraneum, par M. E. Haug; Sur quelques points de la Géologie de la Tunisie, par M. Aubert; Note sur les travertins à végétaux de Douvres (Ain), par M. A. Boistel; Etude sur la formation de la région Théziers-Vacquières (Gard), par M. Caziot; De la mesure du temps par les phénomènes de sédimentation, par M. A. de Lapparent; Les Tremblements de Terre, par M. Tardy; Sur une forme nouvelle de trilobite de la famille des Calymenidæ (Genre Calymenella), par M. Jules Bergeron; Contribution à l'étude du terrain tertiaire d'Alsace et des environs de Mulhouse, par MM. Mieg, Bleicher et Fliche. No. 6, Septembre, 1890: Les Terrians jurassiques dans les environs de Tiaret, Frenda et Saïda, par M. Welsch; Sur les Terrains phosphates des environs de Doullens. Etage Senonien et Terrains superposés, par M. H. Lasne; Monoceros et Parmacella du Pliocène de Montpellier d'apres P. Gervais, par M. Viguier; Les terrains crétacés du Seressou occidental et de Lehon, départment d'Oran, Algérie, par M. J. Welsch. No. 7, Octobre, 1890: Description des Syénites néphéliniques de Pouzac (Hautes-Pyrénées) et de Montréal (Canada) et de leurs phenomenes de contact, par M. A. Lacroix; Etude de la Faune des Couches tithoniques de l'Ardèche, par M. A. Toucas. No. 8, Decembre, 1890: Découverte de fossiles du Miocène superieur dans les sables rouges de la forêt du Gâvre (Loire-Inférieure), par M. L. Davy; Note sur la constitution geologique des Pyrénées. Le systeme cambrien, par M. E. Jacquot. No. 9, Aout, 1891: Situation stratigraphique des regions volcaniques de l'Auvergne, par M. A. Michel Levy; La Chaine des Puys, par M. A. Michel Levy; Le Monte-Dore et ses alentours, par M. A Michel Levy; Sur les enclaves des trachytes du Monte-Dore et en particulier sur leurs enclaves de roches volcaniques, par M. A. Lacroix; Note sur les Andésites à hypersthène du Cantal, par M. A. Lacroix; Pépérites du Puy de Mur, par M. Paul Gautier; Note sur les Zéolites des Basaltes et Pépérites du Puy de Dôme, par M. F. Gonnard; Sur les Tufs volcaniques de Beaulieu (Bouches-du-Rhone), par M. Collot; Basalte de Beaulieu, par M. Depéret; Observation sur les tufs et brèches basaltiques de l'Auvergne et du Velay, par M. M. Boule; Les Anciens Glaciers de l'Auvergne, par M. Tardy; Sur la Limite entre le Pliocène et le Quaternaire, par M. M. Boule; Note sur lâge des Basaltes du Velay, par M. M Boule. Tome XIX, No. 1, Jan. 1891, contains: Formations des ressauts

de Terrain dits rideaux, par M. A. de Lapparent; Sur quelques Faluns Bleus inconnus du Department des Landes, par M. V. Raulin; Echinides Crétacés des Pyrénées Occidentales, par M. J. Seunes. No. 2, Feb. 1890: Description du Terrain Crétacé dans une partie de la Basse-Provence, par M. Collot; Les Terrains d'Alluvion a Pondichéry, par M. H. Léveillé; Sur les Couches dites Crétacé inférieur des environs de Sougraigne (Aude), par M. E. Jacquot. No. 3, Mars 1891: Présentation d'un Memoirs, par M. J. Seunes; Note sur quelques Questions relatives à la Geologie des Grottos et des eaux Souterraines, par M. L. de Launay et M. E. A. Martel; Note Sur le Gisement Argovien de Trept (Isère), par M. A. deRiaz. No. 4, Avril, 1891: Observations sur les Terrains secondaires et les Terrains primaires des Corbières, par M. J. Roussel; Étude sur le bassin Pliocène de Theziers-Roquemaure (Gard), par M. Caziot. No. 5, Mai, 1891: Sur le Callovien de l'Ouest de la France et sur sa Faune, par M. A. de Grossouvre; Étude d'Ensemble sur les dents des Mammifères Fossiles des environs de Reims, par M. Lemoine; No. 6, Aout, 1891: Recherches expérimentales sur le role possible des gaz à hautes Températures, doués de très fortes Pressions et Animés d'un mouvement fort Rapide, dans divers Phénomènes géologiques, par M. Daubrée; Gisements de Phosphate de Chaux des Hautes-Plateaux de la Tunisie, par M. P. Thomas; Recherches sur quelques roches Ophitiques du sud de la Tunisie, par M. P. Thomas.

Zeitschrift der Gesellschaft für Erdkunde zu Berlin. Band XXVI, 1891. No. 3, contains: Beiträge zur Geographie Central-Brasiliens, von Dr. P. Ehrenreich; Versuch einer Orographie des Kwen-lun, von Dr. G. Wegener.

Jahresb. des Vereins für Naturw. zu Braunschweig, für 1887-88 und 1888-89, contains: Die Geologie, Mineralogie und Paläontologie des Herzogthums Braunschweig und der angrenzenden Landestheile mit Inbegriff des Harzgebirges, von Dr. J. H. Kloos.

Verhand. der Gesell. für Erdkunde zu Berlin, Band XVIII, 1891, No. 6, contains: Die Erforschung der obersten Schichten der Atmosphäre, von Prof. W. Förster.

Notizblatt des Vereins für Erdk. zu Darmstadt und des mittelrheinis chen geologischen Vereins. IV Folge, 2 Heft contains: Das Bohrloch der Gebrüder Becker in der Mauerstrasse zu Darmstadt, von R. Lepsius; Ueber die fossilen Reste aus dem mitteloligocänen Meeressandstein bei Heppenheim an der Bergstrasse, von R. Lepsius; Die Granaten von Auerbach an der Bergstrasse, von E. Moyat; Frittung von Rothliegendem Sandstein in einen Bohrloche, von C. Chelius; Uebersicht über die eruptiven Gesteine der Section Giessen, von A. Streng.

Annales de la Société Géologique du Nord. Tome XVII, 1889-90 contains: Notice explicative de la feuille de Redon, par M. Ch. Barrois; Sur les diabases du Menez-Hom (Finistère), par M. Ch. Barrois; Les Demoiselles de Lihus, par M. J. Gosselet; Excursions géologiques dans environs de Vichy, par M. Gronnier; Ondulations de la craie de la feuille de Cambrai et Rapports de la structure ondulée avec le système hydrographique de cette carte, par M. L. Cayeux; Feuille de Pontivy,

par M. Ch. Barrois; Mémoire sur la "Craie grise" du Nord de la France, par M. L. Cayeux; Sur la composition des Phosphates des environs de Mons, par M. H. Lasne; Découverte de silex taillés à Quiévy (Nord). Note sur leur gisement, par M. L. Cayeux; A propos de la Ciplyte, par M. J. Ortlieb; Sur la composition de la scorie Thomas, d'après MM. les Prof. Bucking et Linck; Sur le phosphate quatri-calcique et la Basicité des silicates des scories Thomas d'après M. G. Hilgenstock; Considerations sur le Bief à silex de l'Artois, par M. J. Gosselet; Note sur le Micraster Gosseleti espèce nouvelle de la Craie blanche des environs de Lille, par M. L. Cayeux; Notes sur le rapport des dépôts carbonifères russes avec ceux de l'Europe occidentale, par M. Tschernichew; Légende de la Feuille de Vannes de la carte géologique de France, par Ch. Barrois; Coup-d'œil sur la composition du Crétacé des environs de Péronne, par M. L. Cayeux; Deux excursions dans le Hundsrück et le Taunus, par M. J. Gosselet; Etude micrographique de la Craie des environs de Lille. Dièves à Inoceramus labiatus, par M. L. Cayeux. Annales XVIII, 1890: Description géologique du Canton de Trelon, par M. J. Gronnier; Etude stratigraphique du Terrain Quaternaire du Nord de la France, par M. J. Ladrière; Carrières de Volvic (Puy-de-Dôme), par Quarré-Reybourbon; Légende de la feuille de Quimper de la carte géologique de France, par Ch. Barrois; Etude stratigraphique du Terrain quaternaire du Nord de la France, par M. J. Ladrière; Leçon d'ouverture du Cours de Minéralogie professé à la Faculté des Sciences de Lille, le 21 Nov., 1890, par M. Gosselet.

The Scientific Proceedings of the Royal Dublin Society. Vol. VI, (N. S.) Part 10. Dec., 1890, contains: Reports on the Zoological Collections made in Torres Straits by Prof. A. C. Haddon, 1888-89; Hydroida and Polyzoa, by R. Kirkpatrick. Vol. VII. Part 1, contains: Reports on the Zoological Collections made in Torres Straits by Prof. A. C. Haddon, 1888-89; Lepidoptera from Murray Island, by G. H. Carpenter and The Land Shells, by Edgar A. Smith; On a Fragment of Garnet Hornfels, by Prof. Sollas. Part 2, contains: A New Species of Tortrix from Tuam, by G. H. Carpenter; The Variolite of Cerroyg Gwladys, Anglesey, by G. A. J. Cole; The Origin of Certain Marbles: A Suggestion, by Profs. Sollas and Cole.

Kurze Uebersicht meiner Hypothese von der geologischen Zeitrechnung, von A. Blytt. From Geol. Fören. Förhandl. Bd. XII, Häft 1. No. 127.

Results of Rain, River and Evaporation. Observations made in New South Wales, during 1889, by H. C. Russell.

Annual Report of the Department of Mines of New South Wales, for the year 1889.

The Scientific Transactions of the Royal Dublin Society. Vol. IV. (N. S.) Part VI. Nov, 1890, contains: On the Fossil Fish of the Cretaceous Formations of Scandinavia, by J. W. Davis. Part VII. Feb. 1891, contains: Survey of Fishing Grounds, West Coast of Ireland, 1890. I. On the Eggs and Larvæ of Teleosteans, by E. W. L. Holt.

Part VIII, June, 1891, contains: The Construction of Telescopic Object-Glasses for the International Photographic Survey of the Heavens, by H. Grubb.

Eleventh Annual Report of the Department of Mines of New South Wales, for the year 1890.

PERSONAL AND SCIENTIFIC NEWS.

GRAND FALLS, LABRADOR.—Messrs. Kenaston and Bryant, the explorers who quite recently returned from a trip to Labrador announce some accurate measurements taken at Grand Falls. The fall is 316 feet, or if the rapids be included the descent would be 500 feet.* The width is 200 feet; but on going back half a mile the river is from 1200 to 1500 feet wide, gradually narrowing until it reaches the falls precipice. After passing over the precipice the river runs for a distance of twenty-five to thirty miles through a narrow canon, the walls of which rise to a hight of from 300 to 400 feet.

SILVER PRODUCTION.—Dr. A. F. Wendt is of the opinion that notwithstanding all authorities to the contrary, the aggregate production of the Potosi silver mines of Bolivia has not exceeded 1,000,000,000 ounces.

IT IS DOUBTFUL IF ANY AMERICAN EXPEDITION of recent years has been so fruitful of good results as that undertaken recently by Messrs. McGee, Ward, and Hill into the southern coastal regions of Mississippi, Tennessee, Louisiana, Texas, and Mexico: the party has returned to Washington with a most valuable collection of data. In Tennessee, Mississippi, and Louisiana they were accompanied by professors Safford, of Tennessee, Hilgard, of California, Smith, of Alabama, and Holmes, of North Carolina, who visited all the historic localities, and in the field discussed and harmonized opinions, and devised methods that will soon result in a clear elucidation of the Neocene features of the Atlantic and Gulf slope.

Messrs. McGee, Ward, and Hill continued the work in Texas and Mexico, and obtained a vast store of information concerning the geographical, geological, and botanical relations of those regions of the United States. The remarkable orographic development of northeastern Mexico was reconnoitred, and the interesting Jurassic and Comanche beds visited, proving beyond doubt the great development of the Lower Cretaceous in that country. Finally the Trinity beds of Texas, a great formation hitherto little appreciated, were visited by Profs. Ward and Hill, resulting

in the discovery by Prof. Ward of a magnificent fossil flora which has hitherto been unknown in that region. The whole party feel greatly indebted to Mr. McGee for the able manner in which he planned and conducted this field symposium, and to his accomplished wife, who accompanied the party in even the roughest and most difficult journeys.

GEOLOGY AT THE UNIVERSITY OF WISCONSIN. There have been an enlargement and a reorganization of the departments of geology and mineralogy recently at Madison, the equipment and teaching force increased and the courses recast with reference to the preparation of professional geologists. The teaching corps embraces Pres. T. C. Chamberlin, and Profs. C. R. Van Hise, Rollin D. Salisbury, and William H. Hobbs, with collateral assistance in chemistry by Profs. Daniells and Hillyer.

AWARD OF THE HAYDEN MEMORIAL MEDAL. The committee appointed by the Academy of Natural Sciences of Philadelphia to award this medal, met on the 20th of October and decided to honor Prof. Edward D. Cope for his many and valuable researches in palæontology and geology.

PROF. N. S. SHALER, of Harvard, has lately been appointed Dean of the Lawrence Scientific School of that university, *vice* Prof. Chaplin, resigned.

MR. W. J. BALDWIN, an instructor in the Michigan Mining School, has been appointed professor of mining engineering at the University of Illinois.

W. R. APPLEBY, of New York, has been appointed mining engineer in the school of mines in the University of Minnesota.

MR. AMOS E. WOODWARD, of Somerville, Mass., a young geologist of much promise, died, after a short illness, of pneumonia, at Castle, Montana, September 18th, aged 26 years. He was engaged last year on the Geological Survey of Missouri, and his most important published work appears in Bulletin No. 3 of that Survey, issued last December, on "The Mineral Waters of Henry, St. Clair, Johnson and Benton Counties." Besides the descriptive text, this report gives twelve analyses of Missouri waters, each of which was conducted in duplicate.

PROF. J. F. WILLIAMS, OF CORNELL UNIVERSITY, died at Ithaca, N. Y., on Nov. 8, of malarial fever, the germs of which he brought from the malarial regions of Arkansas. His age was 29 years. His report on the petrography of the crystalline rocks of Arkansas is soon to be published by the state survey. A more extended sketch of him will appear in a subsequent number of the GEOLOGIST.

PROF. C. S. WILKINSON, THE GOVERNMENT GEOLOGIST of New South Wales, died at Sydney the 23rd of August, at the age of 47 years.

PROF. P. HERBERT CARPENTER, OF ETON COLLEGE, England, died Oct. 21, 1891, at the age of 39 years.

INDEX TO VOL. VIII.

in the discovery by Prof. Ward of a magnificent fossil flora which has hitherto been unknown in that region. The whole party feel greatly indebted to Mr. McGee for the able manner in which he planned and conducted this field symposium, and to his accomplished wife, who accompanied the party in even the roughest and most difficult journeys.

GEOLOGY AT THE UNIVERSITY OF WISCONSIN. There have been an enlargement and a reorganization of the departments of geology and mineralogy recently at Madison, the equipment and teaching force increased and the courses recast with reference to the preparation of professional geologists. The teaching corps embraces Pres. T. C. Chamberlin, and Profs. C. R. Van Hise, Rollin D. Salisbury, and William H. Hobbs, with collateral assistance in chemistry by Profs. Daniells and Hillyer.

AWARD OF THE HAYDEN MEMORIAL MEDAL. The committee appointed by the Academy of Natural Sciences of Philadelphia to award this medal, met on the 20th of October and decided to honor Prof. Edward D. Cope for his many and valuable researches in palæontology and geology.

PROF. N. S. SHALER, of Harvard, has lately been appointed Dean of the Lawrence Scientific School of that university, *vice* Prof. Chaplin, resigned.

MR. W. J. BALDWIN, an instructor in the Michigan Mining School, has been appointed professor of mining engineering at the University of Illinois.

W. R. APPLEBY, of New York, has been appointed mining engineer in the school of mines in the University of Minnesota.

MR. AMOS E. WOODWARD, of Somerville, Mass., a young geologist of much promise, died, after a short illness, of pneumonia, at Castle, Montana, September 18th, aged 26 years. He was engaged last year on the Geological Survey of Missouri, and his most important published work appears in Bulletin No. 3 of that Survey, issued last December, on "The Mineral Waters of Henry, St. Clair, Johnson and Benton Counties." Besides the descriptive text, this report gives twelve analyses of Missouri waters, each of which was conducted in duplicate.

PROF. J. F. WILLIAMS, OF CORNELL UNIVERSITY, died at Ithaca, N. Y., on Nov. 8, of malarial fever, the germs of which he brought from the malarial regions of Arkansas. His age was 29 years. His report on the petrography of the crystalline rocks of Arkansas is soon to be published by the state survey. A more extended sketch of him will appear in a subsequent number of the GEOLOGIST.

PROF. C. S. WILKINSON, THE GOVERNMENT GEOLOGIST of New South Wales, died at Sydney the 23rd of August, at the age of 47 years.

PROF. P. HERBERT CARPENTER, OF ETON COLLEGE, England, died Oct. 21, 1891, at the age of 39 years.

INDEX TO VOL. VIII.

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Y

Z

EMBER, 1891. Vol. VIII. No. 6

9/

THE AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF

GEOLOGY AND ALLIED SCIENCES.

gle Numbers, 35 Cents. Yearly Subscription, $3.50.

CONTENTS:

THE GEOLOGICAL PUBLISHING COMPANY, MINNEAPOLIS.
Entered at the Minneapolis post-office as second-class matter.